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ABSTRACT

This guide is designed to assist teachers conducting a foundation course to prepare students for additional courses of training for entry-level employment in either the residential or commercial and industrial wiring trades. Included in the guide are 17 instructional units and the following sections of information for teachers: guidelines in using the unit components; competency profile; instructional/task analysis; list of related academic and workplace skills; list of tools, equipment, and materials required to complete the assignment/job sheets; a 37-item reference list; and a glossary. The following topics are covered in the instructional units: occupational introduction, general safety and first aid, electrical safety, hand tools, specialty tools and equipment, using trade information, basic equipment, basic theory, direct current circuits, alternating current circuits, wiring methods, conductors, low voltage wiring, overcurrent protection, load centers and safety switches, existing structures, and related mathematics and measuring. Each unit contains some or all of the following: objective sheet, suggested activities, assignment and written test answers, written test, unit evaluation form, teacher supplements, transparency masters, information sheet, student supplements, assignment sheets, and job sheets (lists of criteria for evaluating student performance). (MN)

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BASIC WIRING

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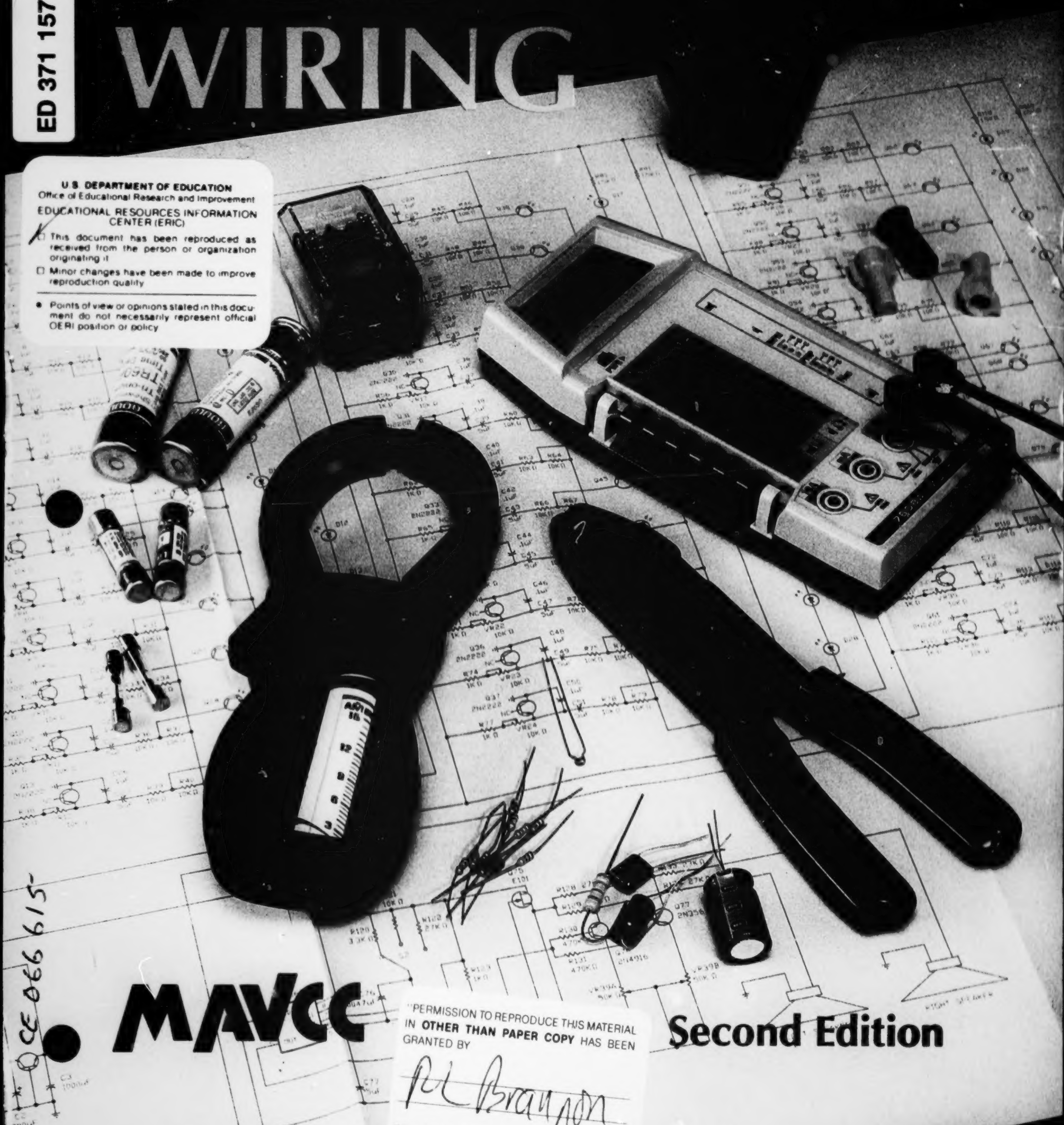

CE 066 615

MAVCC

Second Edition

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Basic Wiring

Second Edition

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Basic Wiring
Second Edition

Teacher Edition

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Foreword

Basic Wiring is the first in a series of three wiring publications and serves as the foundation for students enrolled in a wiring program. It is a prerequisite to either *Commercial and Industrial Wiring* or *Residential Wiring*. An applied math unit has been added in this edition to reinforce computational skills needed in the wiring industry. This series should provide the flexibility that instructors need to meet the individual needs of their students and the community.

Residential Wiring, ©1994, is the second publication in the series and prepares students for entry-level employment in the residential wiring trade. A new unit on SMART HOUSES has been added in the second edition of this publication.

Commercial and Industrial Wiring, ©1994, is the third in a series of three wiring publications and includes the additional technical knowledge and applications required for job entry in the commercial and industrial wiring trade.

MAVCC's wiring series was developed with the assistance of many individuals who have expertise in various areas of the wiring trade. Some of these individuals represent professional associations and industry. Their assistance and support is greatly appreciated. It should be emphasized that the student needs to be aware of professional trade associations and take an active part in them as much as possible. The professional trade associations, as well as vocational education, are an excellent avenue for continuing education within the electrical trade.

These instructional materials are designed not only for student use but also to assist the teacher in improving instruction. Every effort has been made to make these materials basic, readable, and usable. Teachers will need to develop instructional strategies for localizing, individualizing, and supplementing these materials.

Special attention should be given to the list of related academic and workplace skills in the introductory pages and to the teaching suggestions in each unit of instruction. These suggestions present academic skills being reinforced by the instructional materials and ways to increase reinforcement of workplace skills. By reinforcing basic skills, the teacher will assist students in becoming more productive workers.

As you use these instructional materials, we hope you will find they contribute to the quality of your program. If any problems occur or if you have suggestions for improvement, please call or write us.

Mervin Birdwell, Chairman
Board of Directors
Mid-America Vocational
Curriculum Consortium

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Use of Introductory Materials

Introductory materials are included in the teacher edition only and contain useful information to assist administrators and teachers in planning for instruction.

In addition to the general information such as the table of contents, foreword, and acknowledgements page, information is included on the following:

1. **Use of this publication**—Explains the components of a unit of instruction and how they should be used as part of the teaching/ learning process.

2. **Competency profile**—Provides a record of student performance for each task included in a unit of instruction. This becomes a part of the student's permanent records and should be utilized when directing the student toward employment opportunities.

3. **Instructional/task analysis**—Provides a quick review of contents of the publication; identifies cognitive (knowledge) skills and psychomotor (doing) skills addressed in each unit of instruction.

4. **Related academic and workplace skills list**—Classifies unit tasks (assignment sheets and job sheets) according to related academic and workplace skills being reinforced. Skill areas reflected by skill groups, sub skills, and descriptions have been identified using *Workplace Basics: The Skills Employers Want*, developed by the American Society for Training and Development (ASTD) and the U.S. Department of Labor and adapted by MAVCC.

5. **Tools, equipment, and materials list**—Provides a comprehensive list of those items needed to successfully complete the assignment sheets and/or job sheets; assists administrator/teacher in determining program costs.

6. **Reference list**—Provides a comprehensive list of resources used in the development of this publication.

7. **Glossary of terms**—Provides a comprehensive list of terms and definitions found in Objective 1 of all units of instruction.

As you use these materials, it is hoped that they will provide useful information to meet a variety of needs.

Use of This Publication

Instructional units

Basic Wiring contains seventeen units of instruction. Each instructional unit in a teacher edition includes some or all of the following basic components of a unit of instruction: objective sheet, suggested activities for the teacher, answers to assignment sheets, answers to written test, written test, unit evaluation form, teacher supplements, transparency masters, information sheet, assignment sheets, student supplements, and job sheets.

All of the unit components focus on measurable and observable learning outcomes. Teachers are encouraged to supplement, personalize, localize, and motivate with these materials in order to develop a complete teaching/learning process.

Units of instruction are designed for use in more than one lesson or class period of instruction. Careful study of each unit of instruction by the teacher will help to determine the following:

- Amount of materials that can be covered in each class period.
- Skills that must be demonstrated.
- Amount of class time needed for demonstrations.
- Amount of time needed for student practice.
- Supplementary materials, including print and nonprint media and equipment and supplies, that must be ordered.
- Resource people who must be contacted.

Objective sheet (Color code: White)

Each unit of instruction is based on performance objectives which state the goals for successful completion of the course. These performance objectives are stated in two forms: unit objectives which state the expected performance of each student after completion of the unit of instruction, and specific objectives which state what the student must do to reach the unit objective.

The objectives should be provided for students and stressed throughout the teaching/learning process. This will help answer any questions concerning performance requirements for each instructional unit. The objectives can also help determine teaching strategies and instructional methods. Teachers should prepare for each unit by deciding how each objective can best be taught.

Teachers should feel free to modify, delete, or add objectives in order to meet the needs of the students and community. When objectives are added, the teacher should remember to supply the needed information, assignment and/or job sheets, and criterion test items.

Suggested activities (Color code: Pink)

This component is included only in the teacher edition. The suggested activities assist teachers during the preparation stage of the teaching/learning process by providing an instructional plan, teaching suggestions, and a list of supplemental resources. Ways to integrate academic and workplace skills have been included in the teacher suggestions, and skill areas have been noted in bold. (A table of academic and workplace skills with accompanying definitions has been provided on page xv.) The teacher should read the suggested activities before teaching the units and decide how each objective can best be taught. Time should also be allowed to obtain supplemental materials, prepare audiovisual materials, and contact outside resources. Duties of the teacher will vary according to the particular unit.

References used in the development of each unit are listed in the suggested-activities section, along with suggested supplemental resources that may be used to teach the unit. These materials can be used by the teacher to supplement her or his knowledge of the subject area or to help students with particular interests or objectives in the area covered.

Instructions for evaluating student performance on the job sheets are also included in the suggested-activities section. Teachers should select and discuss with students the rating scale that will be used.

Assignment and written test answers (Color code: Pink)

Assignment-sheet answers and written-test answers are designed to assist the teacher in evaluation of student performances.

Written test (Color code: Yellow)

This component provides criterion-referenced evaluation of every cognitive objective listed in the unit of instruction. The test appears in the teacher edition only, but duplication is permitted for student use. If objectives have been added, deleted, or modified, appropriate changes should be made on the written test. It is recommended that the tests be divided into shorter tests covering three or four objectives at a time and given soon after those objectives have been covered. A selection of test items from the units covered may be used for final tests at the end of each term if desired.

Unit evaluation form (Color code: White)

This sheet provides teachers with a record of each students performance on a unit of instruction. It includes space for assignment sheet ratings, job sheet ratings, written test scores, and teacher comments. The unit evaluation form is included in the teacher edition only, but may be duplicated.

Teacher supplements (Color code: White)

This component is included only in the teacher edition. Teacher supplements are optional materials for the teacher to use. They have three purposes: to provide the teacher with higher level materials to stretch the advanced student, with remedial information or practice to assist the less-advanced student, and with state-of-the-art information in which the teacher may not have background or with information that is not readily available in other books. Some teacher supplements may be duplicated for student use and are marked accordingly.

Transparency masters (Color code: White)

Transparencies are included in the teacher edition only and are used to direct the students' attention to the topic of discussion. They may provide illustrations, charts, schematics, or additional information needed to clarify and reinforce objectives included in the unit of instruction.

Information sheet (Color code: Green)

The information sheet provides the content essential for meeting the cognitive (knowledge) objectives of the unit. Teachers will find that the information sheet serves as an excellent guide for presenting background knowledge necessary to develop the skills specified in the unit objective. Students should read the information sheet before the information is discussed in class. Space is provided in margins for students and teachers to add notes that supplement, localize, personalize, or provide information for the teaching of each objective.

Student supplements (Color code: White)

Student supplements are included in the student edition. The information presented in a student supplement may consist of tables, charts, written information, forms, or other information students will need in order to complete one or more of the assignment and/or job sheets. Students are not directly tested over the information presented in a supplement; however, their ability to apply this information may be evaluated in the completion of assignment sheets or job sheets.

Assignment sheets (Color code: Tan)

Assignment sheets provide students with pencil and paper activities that give students the opportunity to make practical application of the knowledge in the information sheet. Criteria are provided to objectively evaluate student performance.

Job sheets (Color code: Blue)

The job sheets provide criteria to objectively evaluate student performance, a list of required equipment and materials, and a step-by-step procedure for performing a psychomotor skill. The teacher should discuss the equipment and materials available in the classroom and/or laboratory and demonstrate the procedure prior to having students practice procedure. When a student is ready to be evaluated, the teacher should follow instructions for evaluating student performance which may be found in the teacher edition.

Job sheets are an important segment of each unit. Job sheets provide potential employers with a picture of the skills being taught during training and the performances that might reasonably be expected from an individual who has had this training.

Disseminating material

Material may be given out a unit or page at a time to keep the material before the student always new. Some teachers ask students to furnish a three-ring binder or folder for the current unit of study. This is convenient for students taking the material home to study. Upon completion, each unit is then placed in a larger binder. Some teachers prefer to store the material by unit in filing cabinets or boxes until needed.

For best results, provide student materials for each student. Student editions contain objective sheets, information sheets, student supplements, assignment sheets, and job sheets. Students should be allowed to take their materials home at the end of the course.

Academic and Workplace Skills
(Classifications and Definitions)

Skill Groups	Sub Skills	Definitions
Learning Skills	Learning to learn	Developing ability to apply knowledge to other situations; knowing how to learn.
Foundation Skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
	Writing	Communicating a thought, idea or fact in written form in a clear, concise manner.
	Math	Applying computation skills such as reasoning, estimation, and problem solving as they are actually used on the job.
	Science	Applying knowledge learned through study or practice that is based on scientific principles as they relate to specific tasks.
Communication Skills	Listening	Listening for content, conversation, long-term contexts, emotional meaning, and directions.
	Oral communication	Communicating a thought, idea, or fact in spoken form in a clear, concise manner.
Adaptability Skills	Creative thinking	Using imagination to create something new—i.e. an idea, invention, work of art.
	Problem solving (critical thinking)	Recognizing and defining problems, inventing, and implementing solutions, and tracking and evaluating results.
Personal Management Skills	Self-esteem	Developing self-confidence and creating a positive self-image.
	Motivation/goal setting	Setting and meeting defined goals and objectives.
	Personal and career development	Emphasizing self-direction by establishing and implementing a plan.
Group Effectiveness Skills	Interpersonal relations	Developing ability to maintain positive relations with others.
	Negotiation	Resolving conflict between two or more individuals.
	Teamwork	Working together in a group to reach a common goal.
Influence Skills	Organizational effectiveness	Adapting to the organization's goals, values, culture, and traditional modes of operation.
	Leadership	Directing/influencing group in performance of a specific task; accepting responsibility for others.

Basic Wiring

Competency Profile

Name: ______________________________

Directions: Evaluate the student using the rating scale below. Write the appropriate number to indicate the degree of competency achieved. The descriptions associated with each of the numbers focus on a level of student performance for each of the tasks listed. The written test scoreline is provided for optional teacher use. It may not be applicable in all cases.

Option A

Rating scale:
4 - Skilled - Can perform job with no additional training.
3 - Moderately Skilled - Has performed job during training program; limited additional training may be required.
2 - Limited Skill - Has performed job during training program; additional training is required to develop skill.
1 - Unskilled - Is familiar with process, but is unable to perform job.
0 - No Exposure - No information or practice provided during training program, complete training required.
NA - Non-applicable.

Option B

Yes - Can perform with no additional training
No - Is unable to perform satisfactorily

Unit 1: Occupational Introduction

______1. Interview an electrical worker.
______2. Compare employment opportunities in the electrical field.
______3. ______________________________

______Written Test Score

Unit 2: General Safety and First Aid

______1. Interpret a material safety data sheet.
______2. Draw a layout of your school shop and apply the safety color code.
______3. Interpret portable fire extinguisher symbols.
______4. Identify and correct safety violations.
______5. Operate a fire extinguisher.
______6. Lift a heavy object properly.
______7. Place and climb a ladder safely.
______8. ______________________________

______Written Test Score

Competency Profile

Unit 3: **Electrical Safety**

______1. Identify and describe safety violations.
______2. Solve problems concerning electrical safety practices.
______3. ____

______Written Test Score

Unit 4: **Hand Tools**

______1. Measure objects using a wood folding rule.
______2. Clean and lubricate an adjustable hand tool.
______3. Use a cutting/crimping tool.
______4. Adjust wire strippers.
______5. Set up and use a hacksaw to cut conduit.
______6. Ream rigid conduit.
______7. Bend EMT conduit.
______8. Use a knockout punch.
______9. Use a hole saw.
______10. ____

______Written Test Score

Unit 5: **Specialty Tools and Equipment**

______1. Use an architect's scale to measure line lengths.
______2. Use a hydraulic knockout punch.
______3. Bend a 90-degree stub using a hydraulic pipe bender.
______4. Make offset and 90-degree bend using an electric PVC heater.
______5. Cut, ream, and thread rigid conduit with a power threader.
______6. Measure resistance using a VOM.
______7. Measure DC voltages using a VOM.
______8. Measure AC voltages using a VOM.
______9. Measure amperage using a clamp-on ammeter.
______10. Determine the current of a multiple loop using a clamp-on ammeter.
______11. Check conductor insulation with a megger.
______12. ____

______Written Test Score

Unit 6: **Using Trade Information**

______1. Use the *National Electrical Code* index to answer questions about *Code* sections.
______2. Use the *National Electrical Code* introduction and first chapter to define terms.
______3. Use the *National Electrical Code* to answer general questions related to residential wiring.

_____4. Use the *National Electrical Code* to locate allowable ampacities for various conductors.
_____5. Use the *National Electrical Code* to interpret conduit fill tables.
_____6. Find information in the *National Electrical Code*.
_____7. ____________________

_____Written Test Score

Unit 7: Basic Equipment

_____1. Determine the correct number of conductors for boxfill.
_____2. Install outlet boxes on wood studs on a framed wall.
_____3. Install outlet boxes on steel structures and rods using caddy clips.
_____4. Install outlet boxes on steel studs using caddy metal stud clips for switch boxes.
_____5. Install masonry boxes in a block wall.
_____6. ____________________

_____Written Test Score

Unit 8: Basic Theory

_____1. Draw a diagram of the power distribution supplying your school shop.
_____2. Solve problems for unknown voltage.
_____3. Solve problems for unknown amperage.
_____4. Solve problems for unknown resistances and wattages.
_____5. Solve problems for an unknown quantity.
_____6. ____________________

_____Written Test Score

Unit 9: DC Circuits

_____1. Solve problems for unknown current.
_____2. Solve problems for unknown resistance.
_____3. Solve problems for unknown voltage.
_____4. Determine total resistance in series circuits.
_____5. Determine unknown resistor values in series circuits.
_____6. Solve problems for unknown current in series circuits.
_____7. Solve problems for unknown resistance in series circuits.
_____8. Solve problems for unknown voltage in series circuits.
_____9. Apply Kirchoff's voltage law to series circuits.
_____10. Solve problems for unknown resistance in parallel circuits.
_____11. Solve problems for unknown current in parallel circuits.
_____12. Apply Kirchoff's current law to parallel circuits.
_____13. Solve problems for unknown resistance in series-parallel circuits.
_____14. Solve problems for unknown voltage in series-parallel circuits.
_____15. Solve problems for unknown current in series-parallel circuits.

Competency Profile

______16. Compute power using Ohm's law
______17. ______________________________

______Written Test Score

Unit 10: AC Circuits

______1. Solve power factor problems.
______2. Solve RC and RL circuit problems.
______3. Draw a diagram of a single-pole switch on a light.
______4. Draw a diagram of two three-way switches on a light.
______5. Draw a diagram of two three-way switches and a four-way switch on a light.
______6. Wire a single-pole switch controlling a single lighting outlet with the supply line entering the switch box.
______7. Wire a single-pole switch controlling a single lighting outlet with the supply line entering the lighting outlet box.
______8. Wire a three-way switching situation with the supply line entering a single lighting outlet.
______9. Wire a four-way switching situation with the supply line entering the lighting outlet box.
______10. ______________________________

______Written Test Score

Unit 11: Wiring Methods

______1. Reference the *National Electrical Code* to identify uses of wiring methods.
______2. Install a set-screw conduit fitting.
______3. Install a compression-type conduit fitting.
______4. Braid the ground conductor of a service entrance cable.
______5. Install an ENT coupling and connector on ENT conduit.
______6. ______________________________

______Written Test Score

Unit 12: Conductors

______1. Select conductors for various ampacities and temperatures.
______2. Calculate ampacity of conductors, given number of conductors in raceway.
______3. Calculate ampacity and conductor sizes for specific types of loads.
______4. Select cords for various applications.
______5. Select proper types of insulation.
______6. Install cord on utilization equipment.
______7. Use a fish tape to install wire in conduit.

______8. Prepare an aluminum conductor for termination.
______9. ____

______Written Test Score

Unit 13: Low Voltage Wiring

______1. Draw a wiring diagram indicating the proper connection for bell circuit equipment.
______2. Wire a two-switch low voltage lighting circuit.
______3. Wire a two-button chime circuit.
______4. Determine heat anticipator current draw.
______5. Install a wall thermostat
______6. ____

______Written Test Score

Unit 14: Overcurrent Protection

______1. Calculate fuse sizes.
______2. Test cartridge fuses.
______3. ____

______Written Test Score

Unit 15: Load Centers and Safety Switches

______1. Using the *NEC*, answer questions related to load centers.
______2. Install a safety switch.
______3. Wire a load center or breaker panel.
______4. Wire a receptacle circuit to a load center.
______5. ____

______Written Test Score

Unit 16: Existing Structures

______1. Determine the number of conductors allowed to be added to an existing conduit.
______2. Install a box with dry-wall grips in a plasterboard wall.
______3. Secure a box with dry-wall supports (box tins).
______4. Install a box in a lath and plaster wall.
______5. Install a box in a paneled wall.
______6. Install a box in a concrete block wall.
______7. Install a box in a brick wall.
______8. Install a box in a ceiling with an accessible attic.
______9. Install cable between an existing box and a newly installed box horizontally along a wall in a channel behind base board.

Competency Profile

______10. Install cable between an existing box and a newly installed box, using an underfloor crawl space.
______11. Install cable between an existing box and a newly installed box, using attic space.
______12. ____

______Written Test Score

Unit 17: Related Math and Measuring

______1. Add whole numbers.
______2. Subtract whole numbers.
______3. Multiply whole numbers.
______4. Divide whole numbers.
______5. Reduce fractions to lowest terms.
______6. Convert fractions and mixed numbers.
______7. Add fractions.
______8. Subtract fractions.
______9. Multiply fractions.
______10. Add decimal numbers.
______11. Subtract decimal numbers.
______12. Multiply decimal numbers.
______13. Divide decimal numbers.
______14. Convert fractions and percentages.
______15. Solve percentage problems.
______16. Calculate area of geometric figures.
______17. ____

______Written Test Score

COMMENTS: ____

____

____

____

____

Evaluator: ______________________ Date: ______________

*** Permission to duplicate this profile is granted.**

Basic Wiring

Instructional/Task Analysis

Related Information: What the Student Should Know	Application: What the Student Should Be Able to Do
Unit 1: Occupational Introduction	
1. Definitions of *NEC* and occupation	11. Interview an electrical worker
2. Major purposes of the *NEC*	12. Compare employment opportunities in the electrical field
3. Areas the *NEC* is intended to cover	
4. Areas the *NEC* is not intended to cover	
5. Job responsibilities of electrical workers	
6. Desirable physical abilities of electrical workers	
7. Employment opportunities in the electrical field	
8. Occupational hazards related to electrical work	
9. Electrical trade organizations and their descriptions	
10. Code compliance	
Unit 2: General Safety and First Aid	
1. Terms and definitions	
2. Guidelines for dressing safely on the job	
3. General job and shop safety rules	
4. Shop conditions that should be reported	
5. OSHA's role in workplace health and safety	

Instructional/Task Analysis

Unit 2: (Cont.)

Related Information: What the Student Should Know	Application: What the Student Should Be Able to Do
6. Hazardous cleaners and lubricants	
7. Storage of hazardous materials	
8. Common hazardous materials found at the job site	
9. Purposes of material safety data sheets (MSDS)	
10. Ways hazardous materials can enter the body	
11. Colors of the safety color code and their uses	
12. Safety tags with their color coding	
13. Components of the fire triangle	
14. Types of fires and their classifications	
15. Fire extinguisher general operating instructions that follow the letters P-A-S-S	
16. General types of fire extinguishers	
17. Causes of back injuries and their contributing factors	
18. Guidelines for lifting and moving items safely	
19. Guidelines for preventing slips, trips, and falls	
20. Rules for using ladders safely	
21. Safety guidelines for using scaffolds	
22. Safety guidelines for using power lifts	

Instructional/Task Analysis

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 2: (Cont.)

23. General steps for handling any emergency situation
24. General guidelines for first-aid emergencies
25. Basic first aid procedures for various emergency situations

26. Interpret a material safety data sheet
27. Draw a layout of your school shop and apply the safety color code
28. Interpret portable fire extinguisher symbols
29. Identify and correct safety violations
30. Operate a fire extinguisher
31. Lift a heavy object properly
32. Place and climb a ladder safely

Unit 3: Electrical Safety

1. Terms and definitions
2. Major causes of electrical accidents
3. Basic electrical safety practices
4. Electrical fire prevention practices
5. Safety practices around live circuits
6. Proper grounding
7. Importance of the third wire
8. Ground-fault circuit-interrupters
9. Instances when lockout devices should be used
10. Electrical shock
11. Facts about treating a victim of electrical shock

12. Identify and describe safety violations
13. Solve problems concerning electrical safety practices

Instructional/Task Analysis

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 4: Hand Tools

1. Terms and definitions
2. Common hand tools used in the electrical field
3. Electricity-specific hand tools used in the electrical field
4. Common hand tools and their uses
5. Electricity-specific hand tools and their uses
6. Factors to consider when purchasing hand tools
7. Rules for care of various hand tools
8. Measure objects using a wood folding rule
9. Clean and lubricate an adjustable hand tool
10. Use a cutting/crimping tool
11. Adjust wire strippers
12. Set up and use a hacksaw to cut conduit
13. Ream rigid conduit
14. Bend EMT conduit
15. Use a knockout punch
16. Use a hole saw

Unit 5: Specialty Tools and Equipment

1. Terms and definitions
2. Typical power equipment
3. General safety rules for using power equipment
4. Parts of a hydraulic knockout set
5. Specific safety rules for using hydraulic equipment
6. Parts of a hydraulic bender
7. Safety rules for using hydraulic pipe benders
8. Parts of an electrical polyvinyl chloride (PVC) heater

Instructional/Task Analysis

Unit 5: (Cont.)

Related Information: What the Student Should Know

9. Specific safety rules for using electric polyvinyl chloride (PVC) heaters
10. Parts of a power drill
11. Specific safety rules for using power drills
12. Parts of a power threader
13. Specific safety rules for using power threaders
14. Typical rules and scales
15. Typical test equipment

Application: What the Student Should Be Able to Do

16. Use an architect's scale to measure line lengths
17. Use a hydraulic knockout punch
18. Bend a 90-degree stub using a hydraulic punch
19. Make offset and 90-degree bends using an electric PVC heater
20. Cut, ream, and thread rigid conduit with a power threader
21. Measure resistance using a VOM
22. Measure DC voltages using a VOM
23. Measure AC voltages using a VOM
24. Measure amperage using a clamp-on ammeter
25. Determine the current of a multiple-loop clamp-on ammeter
26. Check conductor insulation with a megger

Unit 6: Using Trade Information

1. Terms and definitions
2. Purpose of the *National Electrical Code*
3. Factors that are not covered by the *National Electrical Code*
4. Intent of the *National Electrical Code* regarding mandatory enforcement

Instructional/Task Analysis

Related Information: What the Student Should Know	Application: What the Student Should Be Able to Do

Unit 6: (Cont.)

Related Information: What the Student Should Know	Application: What the Student Should Be Able to Do
5. *National Electrical Code* chapter numbers and their areas of application	8. Use the *National Electrical Code* index to answer questions about *Code* sections
6. Sequence of organizational components of *National Electrical Code* information	9. Use the *National Electrical Code* introduction and first chapter to define terms
7. Steps for finding information in the *National Electrical Code*	10. Use the *National Electrical Code* to answer general questions related to residential wiring
	11. Use the *National Electrical Code* to locate allowable ampacities for various conductors
	12. Use the *National Electrical Code* to interpret conduit fill tables
	13. Find information in the *National Electrical Code*

Unit 7: Basic Equipment

1. Terms and definitions
2. Classes of outlet boxes used in electrical wiring
3. Information needed to calculate boxfill
4. Types of enclosures and their conditions for use
5. Purposes of controller enclosures
6. Types of devices commonly used in electrical wiring
7. Types of covers and plates used in electrical wiring

Instructional/Task Analysis

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 7: (Cont.)

8. Supports and anchors commonly used in electrical wiring
9. Screws, bolts, and nuts commonly used in electrical wiring
10. Classes of box mounting devices for steel structures

11. Determine the correct number of conductors for boxfill
12. Install outlet boxes on wood studs on a framed wall
13. Install outlet boxes on steel structures and rods using caddy clips
14. Install outlet boxes on steel studs using caddy metal stud clips for switch boxes
15. Install masonry boxes in a block wall

Unit 8: Basic Theory

1. Terms and definitions
2. Principles of electron flow
3. Basic sources of electrical generation
4. Distribution of electricity
5. Electrical schematic symbols
6. Diagrams and schematics
7. Letters and their terms
8. Ohm's law
9. Ohm's law in wheel expression
10. Uses of Ohm's law
11. Unit of measure formula for Ohm's law

Instructional/Task Analysis

Unit 8: (Cont.)

Related Information: What the Student Should Know

12. Ohm's law for power
13. Ohm's law for power in wheel expression
14. Uses of Ohm's law for power
15. Unit of measure formulas from Ohm's law for power

Application: What the Student Should Be Able to Do

16. Draw a diagram of the power distribution supplying your school shop
17. Solve problems for unknown voltages
18. Solve problems for unknown amperage
19. Solve problems for unknown resistances and wattages
20. Solve problems for an unknown quantity

Unit 9: DC Circuits

Related Information: What the Student Should Know

1. Terms and definitions
2. Applications of DC circuits
3. Application of Ohm's law to direct current
4. Characteristics of series circuits
5. Three basic formulas for Watt's law
6. Kirchoff's voltage law
7. Characteristics of parallel circuits
8. Kirchoff's current law
9. Characteristics of series-parallel circuits
10. Facts about magnetism

Application: What the Student Should Be Able to Do

11. Solve problems for unknown current
12. Solve problems for unknown resistance
13. Solve problems for unknown voltage
14. Determine total resistance in series circuits
15. Determine unknown resistor values in series circuits
16. Solve problems for unknown current in series circuits
17. Solve problems for unknown resistance in series circuits
18. Solve problems for unknown voltage in series circuits
19. Apply Kirchoff's voltage law to series circuits

Instructional/Task Analysis

Related Information: What the Student Should Know	Application: What the Student Should Be Able to Do
Unit 9: (Cont.)	
	20. Solve problems for unknown resistance in parallel circuits
	21. Solve problems for unknown current in parallel circuits
	22. Apply Kirchoff's current law to parallel circuits
	23. Solve problems for unknown resistance in series-parallel circuits
	24. Solve problems for unknown voltage in series-parallel circuits
	25. Solve problems for unknown current in series-parallel circuits
	26. Compute power using Ohm's law
Unit 10: AC Circuits	
1. Terms and definitions	
2. Principles of AC theory	
3. Principles of induction	
4. Inductance characteristics	
5. Factors affecting inductors	
6. Power characteristics in inductive circuits	
7. Transformer characteristics	
8. Classes of transformers	
9. Single-phase transformer connections	

Instructional/Task Analysis

Unit 10: (Cont.)

Related Information: What the Student Should Know

10. Other transformer connections found in electrical trades
11. Power in three-phase circuits
12. Testing for polarity
13. Capacitance characteristics
14. Types, ratings, and common defects of capacitors
15. Capacitive AC RC circuits
16. Inductive AC circuits
17. Power characteristics in AC circuits
18. Basic switching circuits used in electricity

Application: What the Student Should Be Able to Do

19. Solve power factor problems
20. Solve RC and RL circuit problems
21. Draw a diagram of a single-pole switch on a light
22. Draw a diagram of two three-way switches on a light
23. Draw a diagram of two three-way switches and a four-way switch on a light
24. Wire a single-pole switch controlling a single lighting outlet with the supply line entering the switch box
25. Wire a single-pole switch controlling a single lighting outlet with the supply line entering the lighting outlet box
26. Wire a three-way switching situation with the supply line entering a single lighting outlet
27. Wire a four-way switching situation with the supply line entering the lighting outlet box

Unit 11: Wiring Methods

Related Information: What the Student Should Know

1. Terms and definitions
2. Wiring methods found in electrical trades
3. Wiring methods and their common applications

Application: What the Student Should Be Able to Do

4. Reference the *National Electrical Code* to identify uses of wiring methods
5. Install a set-screw conduit fitting
6. Install a compression-type conduit fitting

Instructional/Task Analysis

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 11: (Cont.)

7. Braid the ground conductor of a service entrance cable
8. Install an ENT coupling and connector on ENT conduit

Unit 12: Conductors

1. Terms and definitions
2. Factors that determine conductor type and size
3. Characteristics of good connections
4. Types of connectors, terminals, and lugs
5. Types of insulation, its characteristics, applications, and code letters
6. Conductors commonly found in electrical wiring
7. Types of cables found in the electrical field
8. Cords and their conductors
9. Cables and their conductors

10. Select conductors for various ampacities and temperatures
11. Calculate ampacity of conductors, given number of conductors in raceway
12. Calculate ampacity and conductor sizes for specific types of loads
13. Select cords for various applications
14. Select proper types of insulation
15. Install cord on utilization equipment
16. Use a fish tape to install wire in conduit
17. Prepare an aluminum conductor for termination

Unit 13: Low Voltage Wiring

1. Terms and definitions
2. Parts of a low voltage wiring system
3. Process that takes place during a low voltage lighting circuit off/on cycle

Instructional/Task Analysis

Unit 13: (Cont.)

Related Information: What the Student Should Know

4. Process that takes place during the energizing of a chime circuit
5. Manual fan switching circuit
6. Thermostat system switch in the cool position and the fan switch on auto
7. Thermostat system switch in the heat position and the fan switch on auto
8. Anticipator circuits on low voltage thermostats
9. Communication circuits and their characteristics
10. Smoke and fire alarm systems

Application: What the Student Should Be Able to Do

12. Draw a wiring diagram indicating the proper connection for bell circuit equipment
13. Wire a two-switch low voltage lighting circuit
14. Wire a two-button chime circuit
15. Determine heat anticipator current draw
16. Install a wall thermostat

Unit 14: Overcurrent Protection

Related Information: What the Student Should Know

1. Terms and definitions
2. Types of overcurrent protective devices
3. Operation of a single-element fuse
4. Operation of a dual-element, time-delay fuse
5. Types of circuit breakers and their operation
6. Requirements for fuses of less than 600 volts
7. Requirements for circuit breakers of less than 600 volts
8. Installations that require GFCI protection

Application: What the Student Should Be Able to Do

9. Calculate fuse sizes
10. Test cartridge fuses

Instructional/Task Analysis

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 15: Load Centers and Safety Switches

1. Terms and definitions
2. Types of safety switch enclosures
3. Safety switch system configurations
4. Types of load centers and enclosures
5. Common load center accessories and their fuses
6. Parts of a fusible, single-phase load center
7. Parts of a breaker load center
8. Common panel bus configurations
9. Safety rules for working near load centers and safety switches
10. Using the *NEC*, answer questions related to load centers
11. Install a safety switch
12. Wire a load center or breaker panel
13. Wire a receptacle circuit to a load center

Unit 16: Existing Structures

1. Terms and definitions
2. Construction members common in existing structures
3. Common routes for new cable installations
4. Possible methods for getting cable through or around construction members
5. Wall or ceiling compositions that may be found n an existing structure
6. Conditions for using optional calculations for additional loads to existing installations

Instructional/Task Analysis

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 16: (Cont.)

7. Exceptions to the *NEC* requirements for support of flexible metal conduit
8. Steps for determining the number of conductors allowed in a conduit, based on cross-sectional area

9. Determine the number of conductors allowed to be added to an existing conduit
10. Install a box with dry-wall grips in a plasterboard wall
11. Secure a box with dry-wall supports
12. Install a box in a lath and plaster wall
13. Install a box in a paneled wall
14. Install a box in a concrete block wall
15. Install a box in a brick wall
16. Install a box in a ceiling with an accessible attic
17. Install cable between an existing box and a newly installed box horizontally along a wall in a channel behind base board
18. Install cable between an existing box and a newly installed box, using an underfloor crawl space
19. Install cable between an existing box and a newly installed box, using attic space

Unit 17: Related Math and Measuring

1. Terms and definitions
2. Symbols used in math problems
3. Place values of a whole number
4. Adding whole numbers

Instructional/Task Analysis

Related Information: What the Student Should Know	Application: What the Student Should Be Able to Do

Unit 17: (Cont.)

5. Subtracting whole numbers
6. Multiplying whole numbers
7. Dividing whole numbers
8. Types of fractions
9. Reducing fractions to lowest terms
10. Converting fractions and mixed numbers
11. Adding fractions
12. Subtracting fractions
13. Multiplying fractions
14. Placing values for a decimal number
15. Adding decimal numbers
16. Subtracting decimal numbers
17. Multiplying decimal numbers
18. Dividing decimal numbers
19. Converting fractions and percentages
20. Solving percentage problems
21. Terms used in geometry and their definitions
22. Types of geometric figures and their descriptions
23. Units of measure and their equivalents

Instructional/Task Analysis

Related Information: What the Student Should Know

Unit 17: (Cont.)

24. Calculating area of geometric figures
25. Metric prefixes and their values
26. English and metric rules

Application: What the Student Should Be Able to Do

27. Add whole numbers
28. Subtract whole numbers
29. Multiply whole numbers
30. Divide whole numbers
31. Reduce fractions to lowest terms
32. Convert fractions and mixed numbers
33. Add fractions
34. Subtract fractions
35. Multiply fractions
36. Add decimal numbers
37. Subtract decimal numbers
38. Multiply decimal numbers
39. Divide decimal numbers
40. Convert fractions and percentages
41. Solve percentage problems
42. Calculate area of geometric figures

Related Academic and Workplace Skills
For *Basic Wiring*

Task	Skill Group	Sub Skill	Description
Unit 1: Occupational Introduction			
Interview an electrical worker (A.S. 1)	Foundation Skills	Reading	Determines what information is needed; follows written directions
		Writing	Presents answers/conclusions in a clear and understandable form
	Communication Skills	Listening	Listens for content
		Oral communication	Asks questions to obtain information; communicates a thought, idea, or fact in spoken form
	Learning Skills	Learning to learn	Processes new information as related to workplace
	Personal Management Skills	Personal and career development	Explores career opportunities
Compare employment opportunities in the electrical field (A.S. 2)	Foundation Skills	Reading	Determines what information is needed; analyzes and applies what has been read to specific task; follows written directions
		Writing	Communicates a fact in written form in a clear, concise manner; organizes sentences into paragraphs; applies rules of grammar, punctuation, capitalization, and spelling; writes/prints legibly
	Communication Skills	Oral communication	Communicates a thought, idea, or fact in spoken form; speaks in a clear, concise manner
		Listening	Listens for content
	Adaptability Skills	Problem solving	Demonstrates logical reasoning in reaching a conclusion
	Personal Management Skills	Personal and career development	Evaluates career opportunities

Related Academic and Workplace Skills
For *Basic Wiring*

Task	Skill Group	Sub Skill	Description
Unit 2: General Safety and First Aid			
Interpret a material safety data sheet (A.S. 1)	Foundation Skills	Reading	Analyzes and applies what has been read to specific task; follows written directions
		Writing	Prepares answers in a clear and understandable form; writes/prints legibly
		Science	Determines appropriate health/safety measures in handling hazardous materials; interprets health hazard data
Draw a layout of your school shop and apply the safety color code (A.S. 2)	Foundation Skills	Reading	Follows written directions; applies information to job performance
	Adaptability Skills	Creative thinking	Creates a drawing to convey information and to show understanding of basic concepts/ideas
Interpret portable fire-extinguisher symbols (A.S. 3)	Foundation Skills	Reading	Recalls important details from written information; follows written directions
Identify and correct safety violations (A.S. 4)	Foundation Skills	Reading	Draws conclusions from what has been read; recalls important details from written information
		Writing	Communicates a fact in written form in a clear, concise manner; writes/prints legibly
	Adaptability Skills	Problem solving	Recognizes problems and gives solutions
Operate a fire extinguisher (J.S. 1)	Foundation Skills	Reading	Reads and follows instructions to operate technical equipment; uses appropriate materials and techniques as specified
	Influence Skills	Organizational effectiveness	Adapting to the organizations traditional modes of operation
Lift a heavy object properly (J.S. 2)	Foundation Skills	Reading	Comprehends written information; applying what has been read to a specific task
	Influence Skills	Organizational effectiveness	Adapting to the organization's traditional modes of operation

Related Academic and Workplace Skills For *Basic Wiring*

Task	Skill Group	Sub Skill	Description
Unit 2: (Cont.)			
Place and climb a ladder safely (J.S. 3)	Foundation Skills	Reading	Comprehends written information; applying what has been read to a specific task
	Influence Skills	Organizational effectiveness	Adapting to the organization's traditional modes of operation
	Group Effectiveness Skills	Teamwork	Working together to reach a common goal
Unit 3: Electrical Safety			
Identify and describe safety violations (A.S. 1)	Foundation Skills	Reading	Uses checklist to obtain factual information; follows written directions
		Writing	Records data through observation; presents answers/conclusions in a clear and understandable form; writes/prints legibly
	Adaptability Skills	Problem solving	Draws conclusions from observations; recognizes/defines problems
Solve problems concerning electrical safety practices (A.S. 2)	Foundation Skills	Reading	Comprehends written information for main idea; draws conclusions from what is read; follows written directions
		Writing	Presents answers/conclusions in a clear and understandable form; writes/prints legibly
	Adaptability Skills	Problem solving	Recognizes problems and gives solutions
Unit 4: Hand Tools			
Measure objects using a wood folding rule (A.S. 1)	Foundation Skills	Math	Takes measurements using a common measuring device
Clean and lubricate an adjustable hand tool (J.S. 1)	Foundation Skills	Reading	Applies information to job performance; uses appropriate materials and techniques as specified
Use a cutting/crimping tool (J.S. 2)	Foundation Skills	Reading	Applies information to job performance; reads and follows instructions to use tool

Related Academic and Workplace Skills
For *Basic Wiring*

Task	Skill Group	Sub Skill	Description
Unit 4: (Cont.)			
Adjust wire strippers (J.S. 3)	Foundation Skills	Reading	Applies information to job performance; uses appropriate materials and techniques as specified
Set up and use a hacksaw to cut conduit (J.S. 4)	Foundation Skills	Reading	Applies information to job performance; uses appropriate materials and techniques as specified
Ream rigid conduit (J.S. 5)	Foundation Skills	Reading	Applies information to job performance; uses appropriate materials and techniques as specified
Bend EMT conduit (J.S. 6)	Foundation Skills	Reading	Applies information to job performance; uses appropriate materials and techniques as specified
Use a knockout punch (J.S. 7)	Foundation Skills	Reading	Applies information to job performance; uses appropriate materials and techniques as specified
Use a hole saw (J.S. 8)	Foundation Skills	Reading	Applies information to job performance; uses appropriate materials and techniques as specified
Unit 5: Specialty Tools and Equipment			
Use an architect's scale to measure line lengths (A.S. 1)	Foundation Skills	Reading	Follows written directions
		Math	Draws lines to scale using common measuring device
Use a hydraulic knockout punch (J.S. 1)	Foundation Skills	Reading	Applies information to job performance; uses appropriate materials and techniques as specified; uses written resources to obtain specific instructions/information

Related Academic and Workplace Skills For *Basic Wiring*

Task	Skill Group	Sub Skill	Description
Unit 5: (Cont.)			
Bend a 90-degree stub using a hydraulic pipe bender (J.S. 2)	Foundation Skills	Reading	Uses chart to obtain specific requirements; applies information to job performance; uses appropriate materials and techniques as specified
		Math	Makes precision measurements using common measuring device—height, degree of bend; applies computation skills as used on job-subtraction
Make offset and 90-degree bend using an electric PVC heater (J.S. 3)	Foundation Skills	Reading	Applies information to job performance; uses appropriate materials and techniques as specified; uses written resources to obtain specific instructions/information
Cut, ream, and thread rigid conduit with a power threader (J.S. 4)	Foundation Skills	Reading	Applies information to job performance; uses appropriate materials and techniques as specified; uses written resources to obtain specific instructions/information
Measure resistance using a VOM (J.S. 5)	Foundation Skills	Reading	Applies information to job performance; uses appropriate equipment and techniques as specified; reads measuring device to obtain specific data
		Writing	Records instrument readings
		Math	Operates technical equipment to determine ohmic value
Measure DC voltages using a VOM (J.S. 6)	Foundation Skills	Reading	Applies information to job performance; uses appropriate equipment and techniques as specified; reads measuring device to obtain specific data
		Writing	Records instrument readings
		Math	Operates technical equipment to measure voltage

Related Academic and Workplace Skills
For *Basic Wiring*

Task	Skill Group	Sub Skill	Description
Unit 5: (Cont.)			
Measure AC voltages using a VOM (J.S. 7)	Foundation Skills	Reading	Applies information to job performance; uses appropriate equipment and techniques as specified; reads measuring device to obtain specific data
		Writing	Records instrument readings
		Math	Operates technical equipment to measure voltage
Measure amperage using a clamp-on ammeter (J.S. 8)	Foundation Skills	Reading	Applies information to job performance; uses appropriate equipment and techniques as specified; reads measuring device to obtain specific data
		Writing	Records instrument readings
		Math	Operates technical equipment to measure voltage
Determine the current of a multiple loop using a clamp-on ammeter (J.S. 9)	Foundation Skills	Reading	Applies information to job performance; uses appropriate equipment and techniques as specified; reads measuring device to obtain specific data
		Writing	Records instrument readings
		Math	Operates technical equipment to measure current; calculates current value using division
Check conductor insulation with a megger (J.S. 10)	Foundation Skills	Reading	Applies information to job performance; uses appropriate equipment and techniques as specified; reads measuring device to obtain specific data
		Writing	Records instrument readings
Unit 6: Using Trade Information			
Use the *National Electrical Code* index to answer questions about code sections (A.S. 1)	Foundation Skills	Reading	Uses standard occupational resource materials; determines what information is needed
		Writing	Records data from resource materials

Related Academic and Workplace Skills For *Basic Wiring*

Task	Skill Group	Sub Skill	Description
Unit 6: (Cont.)			
Use the *National Electrical Code* introduction and first chapter to define terms (A.S. 2)	Foundation Skills	Reading	Uses standard occupational resource materials; determines what information is needed
		Writing	Presents answers in a clear and understandable form
Use the *National Electrical Code* to answer general questions related to residential wiring (A.S. 3)	Foundation Skills	Reading	Uses standard occupational resource materials; determines what information is needed
		Writing	Presents answers in a clear and understandable form
Use the *National Electrical Code* to locate allowable ampacities for various conductors (A.S. 4)	Foundation Skills	Reading	Uses standard occupational resource materials; determines what information is needed
		Writing	Records data from resource materials
Use the *National Electrical Code* to interpret conduit fill tables (A.S. 5)	Foundation Skills	Reading	Uses tables to obtain factual information; uses standard occupational resource materials
		Writing	Records data from resource materials
Find information in the *NEC* (A.S. 6)	Foundation Skills	Reading	Uses standard occupational resource materials; determines what information is needed; draws conclusions from what is read
		Writing	Presents answers in a clear and understandable form
Unit 7: Basic Equipment			
Determine the correct number of conductors for boxfill (A.S. 1)	Foundation Skills	Reading	Uses standard occupational resource materials; draws conclusions from what is read
		Math	Applies computation skills as they are actually used on the job—subtraction

Related Academic and Workplace Skills
For *Basic Wiring*

Task	Skill Group	Sub Skill	Description
Unit 7: (Cont.)			
Install outlet boxes on a framed wall (J.S. 1)	Foundation Skills	Reading	Uses blueprint to obtain factual information; applies information to job performance; uses appropriate materials and techniques
		Math	Makes precision measurements using common tools
Install outlet boxes on steel structures and rods using caddy clips (J.S. 2)	Foundation Skills	Reading	Uses standard occupational resource materials; applies information to job performance; uses appropriate materials and techniques
Install outlet boxes on steel studs using caddy metal clips for switch boxes (J.S. 3)	Foundation Skills	Reading	Uses standard occupational resource materials; applies information to job performance; uses appropriate materials and techniques
Install masonry boxes in a block wall (J.S. 4)	Foundation Skills	Reading	Uses standard occupational resource materials; applies information to job performance; uses appropriate materials and techniques
		Math	Makes precision measurements using measuring device; uses basic geometric principles—90° angles
Unit 8: Basic Theory			
Draw a diagram of the power distribution supplying your school shop (A.S. 1)	Foundation Skills	Reading	Analyzes and applies what has been read to specific task
Solve problems for unknown voltage (A.S. 2)	Foundation Skills	Math	Computes using Ohm's law formula
Solve problems for unknown amperage (A.S. 3)	Foundation Skills	Math	Computes using Ohm's law formula; applies computation skills as they are actually used on the job
Solve problems for unknown resistances and wattages (A.S. 4)	Foundation Skills	Math	Computes using Ohm's law formula; applies computation skills as they are actually used on the job

Related Academic and Workplace Skills
For *Basic Wiring*

Task	Skill Group	Sub Skill	Description
Unit 8: (Cont.)			
Solve problems for an unknown quantity (A.S. 5)	Foundation Skills	Reading	Applies information to job performance
		Math	Computes using Ohm's law formula
Unit 9: DC Circuits			
Solve problems for unknown current (A.S. 1)	Foundation Skills	Reading	Applies information to job performance; follows written directions
		Math	Computes using Ohm's law formula
Solve problems for unknown resistance (A.S. 2)	Foundation Skills	Reading	Applies information to job performance; follows written directions
		Math	Computes using Ohm's law formula
Solve problems for unknown voltage (A.S. 3)	Foundation Skills	Reading	Applies information to job performance; follows written directions
		Math	Computes using Ohm's law formula
Determine total resistance in series circuits (A.S. 4)	Foundation Skills	Reading	Reads schematics to solve mathematical problems; follows written directions
		Math	Computes using Ohm's law formula
Determine unknown resistor values in series circuits (A.S. 5)	Foundation Skills	Reading	Reads schematics to solve mathematical problems; follows written directions
		Math	Computes using Ohm's law formula
Solve problems for unknown current in series circuits (A.S. 6)	Foundation Skills	Reading	Reads schematics to solve mathematical problems; follows written directions
		Math	Computes using Ohm's law formula

Related Academic and Workplace Skills
For *Basic Wiring*

Task	Skill Group	Sub Skill	Description
Unit 9: (Cont.)			
Solve problems for unknown resistance in series circuits (A.S. 7)	Foundation Skills	Reading	Reads schematics to solve mathematical problems; follows written directions
		Math	Computes using Ohm's law formula
Solve problems for unknown voltage in series circuits (A.S. 8)	Foundation Skills	Reading	Reads schematics to solve mathematical problems; follows written directions
		Math	Computes using Ohm's law formula
Apply Kirchoff's voltage law to series circuits (A.S. 9)	Foundation Skills	Reading	Reads schematics to solve mathematical problems; follows written directions
		Math	Computes using mathematical formula
Solve problems for unknown resistance in parallel circuits (A.S. 10)	Foundation Skills	Reading	Reads schematics to solve mathematical problems; follows written directions
		Math	Computes using Ohm's law formula
Solve problems for unknown current in parallel circuits (A.S. 11)	Foundation Skills	Reading	Reads schematics to solve mathematical problems; follows written directions
		Math	Computes using Ohm's law formula
Apply Kirchoff's current law to parallel circuits (A.S. 12)	Foundation Skills	Reading	Reads schematics to solve mathematical problems; follows written directions
		Math	Computes using mathematical formula
Solve problems for unknown resistance in series-parallel circuits (A.S. 13)	Foundation Skills	Reading	Reads schematics to solve mathematical problems; follows written directions
		Math	Computes using Ohm's law formula

Related Academic and Workplace Skills For *Basic Wiring*

Task	Skill Group	Sub Skill	Description
Unit 9: (Cont.)			
Solve problems for unknown voltage in series-parallel circuits (A.S. 14)	Foundation Skills	Reading	Reads schematics to solve mathematical problems; follows written directions
		Math	Computes using mathematical formula
Solve problems for unknown current in series-parallel circuits (A.S. 15)	Foundation Skills	Reading	Reads schematics to solve mathematical problems; follows written directions
		Math	Computes using mathematical formula
Compute power using Ohm's law (A.S. 16)	Foundation Skills	Reading	Reads schematics to solve mathematical problems; follows written directions
		Math	Computes using mathematical formula
Unit 10: AC Circuits			
Solve power factor problems (A.S. 1)	Foundation Skills	Reading	Applies information to job performance; follows written directions
		Math	Computes using standard power formula
Solve RC and RL circuit problems (A.S. 2)	Foundation Skills	Reading	Applies information to job performance; follows written directions
		Math	Computes using mathematical formulas
Draw a diagram of a single-pole switch on a light (A.S. 3)	Foundation Skills	Reading	Analyzes and applies what has been read to specific task
Draw a diagram of two three-way switches on a light (A.S. 4)	Foundation Skills	Reading	Analyzes and applies what has been read to specific task
Draw a diagram of two three-way switches and a four-way switch on a light (A.S. 5)	Foundation Skills	Reading	Analyzes and applies what has been read to specific task
Wire a single-pole switch controlling a single lighting outlet with the supply line entering the switch box (J.S. 1)	Foundation Skills	Reading	Applies information to job performance; uses appropriate materials and techniques; uses standard occupational resource materials

Related Academic and Workplace Skills
For *Basic Wiring*

Task	Skill Group	Sub Skill	Description
Unit 10: (Cont.)			
Wire a single-pole switch controlling a single lighting outlet with the supply line entering the lighting outlet box (J.S. 2)	Foundation Skills	Reading	Applies information to job performance; uses appropriate materials and techniques; uses standard occupational resource materials
Wire a three-way switching situation with the supply line entering a single lighting outlet (J.S. 3)	Foundation Skills	Reading	Applies information to job performance; uses appropriate materials and techniques; uses standard occupational resource materials
Wire a four-way switching situation with the supply line entering the lighting outlet box (J.S. 4)	Foundation Skills	Reading	Applies information to job performance; uses appropriate materials and techniques; uses standard occupational resource materials
Unit 11: Wiring Methods			
Reference the *National Electrical Code* to identify uses of wiring methods (A.S. 1)	Foundation Skills	Reading	Uses standard occupational resource materials; determines what information is needed; follows written directions
		Writing	Presents answers in a clear and understandable form
Install a set-screw conduit fitting (J.S. 1)	Foundation Skills	Reading	Applies information to job performance; uses appropriate materials and techniques
Install a compression-type conduit fitting (J.S. 2)	Foundation Skills	Reading	Applies information to job performance; uses appropriate materials and techniques
Braid the ground conductor of a service entrance cable (J.S. 3)	Foundation Skills	Reading	Applies information to job performance; uses appropriate materials and techniques
Install an ENT coupling and connector on ENT conduit (J.S. 4)	Foundation Skills	Reading	Applies information to job performance; uses appropriate materials and techniques
Unit 12: Conductors			
Select conductors for various ampacities and temperatures (A.S. 1)	Foundation Skills	Reading	Uses standards occupational resource materials; uses tables to obtain factual information; comprehends written specifications and applies them to a task; follows written directions

Related Academic and Workplace Skills
For *Basic Wiring*

Task	Skill Group	Sub Skill	Description
Unit 12: (Cont.)			
Calculate ampacity of conductors, given number of conductors in raceway (A.S. 2)	Foundation Skills	Reading	Uses standards occupational resource materials; uses tables to obtain factual information; comprehends written specifications and applies them to a task; follows written directions
Calculate ampacity and conductor sizes for specific types of loads (A.S. 3)	Foundation Skills	Reading	Uses standards occupational resource materials; uses tables to obtain factual information; comprehends written specifications and applies them to a task; follows written directions
Select cords for various applications (A.S. 4)	Foundation Skills	Reading	Uses standards occupational resource materials; uses tables to obtain factual information; comprehends written specifications and applies them to a task; follows written directions
Select proper types of insulation (A.S. 5)	Foundation Skills	Reading	Uses standards occupational resource materials; uses tables to obtain factual information; comprehends written specifications and applies them to a task; follows written directions
Install cord on utilization equipment (J.S. 1)	Foundation Skills	Reading	Uses standard occupational resource materials; comprehends written specifications and applies them to a task; uses appropriate materials and techniques
Use a fish tape to install wire in conduit (J.S. 2)	Foundation Skills	Reading	Applies information to job performance; uses appropriate materials and techniques
Prepare an aluminum conductor for termination (J.S. 3)	Foundation Skills	Reading	Applies information to job performance; uses appropriate materials and techniques
Unit 13: Low Voltage Wiring			
Draw a wiring diagram indicating the proper connection for bell circuit equipment (A.S. 1)	Foundation Skills	Reading	Analyzes and applies what has been read to specific task
Wire a two-switch low voltage lighting circuit (J.S. 1)	Foundation Skills	Reading	Applies information to job performance; uses appropriate materials and techniques

Related Academic and Workplace Skills For *Basic Wiring*

Task	Skill Group	Sub Skill	Description
Unit 13: (Cont.)			
Wire a two-button chime circuit (J.S. 2)	Foundation Skills	Reading	Applies information to job performance; uses appropriate materials and techniques
Determine heat anticipator current draw (J.S. 3)	Foundation Skills	Reading	Applies information to job performance; uses appropriate materials and techniques; reads measuring device to obtain specific data
		Math	Calculates readings taken from measuring device; applies computation skills as used on job
Install a wall thermostat (J.S. 4)	Foundation Skills	Reading	Applies information to job performance; uses appropriate materials and techniques
Unit 14: Overcurrent Protection			
Calculate fuse sizes (A.S. 1)	Foundation Skills	Reading	Uses standard occupational resource materials; comprehends written specifications and applies them to a task; follows written directions
		Math	Calculates percentages; applies addition and multiplication to work situation
Test cartridge fuses (J.S. 1)	Foundation Skills	Reading	Applies information to job performance; uses appropriate equipment and techniques as specified; reads measuring device to check voltage
Unit 15: Load Centers and Safety Switches			
Using the *NEC*, answer questions related to load centers (A.S. 1)	Foundation Skills	Reading	Uses standard occupational resource materials; determines what information is needed
		Writing	Presents answers in a clear and understandable form
Install a safety switch (J.S. 1)	Foundation Skills	Reading	Applies information to job performance; uses appropriate materials and techniques
		Math	Takes measurements using rule

Task	Skill Group	Sub Skill	Description
Unit 15: (Cont.)			
Wire a load center or breaker panel (J.S. 2)	Foundation Skills	Reading	Applies information to job performance; uses appropriate materials and techniques
Wire a receptacle circuit to a load center (J.S. 3)	Foundation Skills	Reading	Uses standard occupational resource materials; applies information to job performance; uses appropriate materials and techniques
Unit 16: Existing Structures			
Determine the number of conductors allowed to be added to an existing conduit (A.S. 1)	Foundation Skills	Reading	Uses standard occupational resource materials; determines what information is needed; follows written directions
		Math	Applies computation skills as they are actually used on the job
Install a box with dry-wall grips in a plasterboard wall (J.S. 1)	Foundation Skills	Reading	Applies information to job performance; uses appropriate materials and techniques
Secure a box with dry-wall supports (J.S. 2)	Foundation Skills	Reading	Applies information to job performance; uses appropriate materials and techniques
Install a box in a lath and plaster wall (J.S. 3)	Foundation Skills	Reading	Applies information to job performance; uses appropriate materials and techniques
Install a box in a paneled wall (J.S. 4)	Foundation Skills	Reading	Applies information to job performance; uses appropriate materials and techniques
Install a box in a concrete block wall (J.S. 5)	Foundation Skills	Reading	Applies information to job performance; uses appropriate materials and techniques
		Math	Makes rough measurements—estimates
Install a box in a brick wall (J.S. 6)	Foundation Skills	Reading	Applies information to job performance; uses appropriate materials and techniques
		Math	Makes rough measurements

Related Academic and Workplace Skills For *Basic Wiring*

Task	Skill Group	Sub Skill	Description
Unit 16: (Cont.)			
Install a box in a ceiling with an accessible attic (J.S. 7)	Foundation Skills	Reading	Uses standard occupational resource materials; applies information to job performance; uses appropriate materials and techniques
Install cable between an existing box and a newly installed box horizontally along a wall in a channel behind base board (J.S. 8)	Foundation Skills	Reading	Uses standard occupational resource materials; applies information to job performance; uses appropriate materials and techniques
Install cable between an existing box and a newly installed box using an underfloor crawl space (J.S. 9)	Foundation Skills	Reading	Applies information to job performance; uses appropriate materials and techniques
Install cable between an existing box and a newly installed box using an attic space (J.S. 10)	Foundation Skills	Reading	Applies information to job performance; uses appropriate materials and techniques
		Math	Makes precision measurements using a tape
Unit 17: Related Math and Measuring			
Add whole numbers (A.S. 1)	Foundation Skills	Reading	Draws conclusions from what is read; follows written directions
		Math	Applies addition to values in a sequence; solves word problems using addition
Subtract whole numbers (A.S. 2)	Foundation Skills	Reading	Draws conclusions from what is read; follows written directions
		Math	Applies subtraction to values in sequence; solves word problems using subtraction
Multiply whole numbers (A.S. 3)	Foundation Skills	Reading	Draws conclusions from what is read; follows written directions
		Math	Applies multiplication to values in sequence; solves word problems using multiplication
Divide whole numbers (A.S. 4)	Foundation Skills	Reading	Draws conclusions from what is read; follows written directions
		Math	Applies multiplication and division to find answers and to solve word problems

Related Academic and Workplace Skills For *Basic Wiring*

Task	Skill Group	Sub Skill	Description
Unit 17: (Cont.)			
Reduce fractions to lowest terms (A.S. 5)	Foundation Skills	Reading	Follows written directions
		Math	Uses division skills to reduce fractions
Convert fractions and mixed numbers (A.S. 6)	Foundation Skills	Reading	Follows written directions
		Math	Converts fractions/mixed numbers; applies computation skills—addition, subtraction, multiplication, and division
Add fractions (A.S. 7)	Foundation Skills	Reading	Draws conclusions from what is read; follows written directions
		Math	Converts fractions/mixed numbers; applies computation skills—addition, subtraction, multiplication, and division
Subtract fractions (A.S. 8)	Foundation Skills	Reading	Draws conclusions from what is read; follows written directions
		Math	Applies computation skills; solves word problems using subtraction
Multiply fractions (A.S. 9)	Foundation Skills	Reading	Draws conclusions from what is read; follows written directions
		Math	Applies computation skills—multiplication and division
Add decimal numbers (A.S. 10)	Foundation Skills	Reading	Draws conclusions from what is read; follows written directions
		Math	Applies addition to decimal values in a sequence; solves word problems using addition
Subtract decimal numbers (A.S. 11)	Foundation Skills	Reading	Draws conclusions from what is read; follows written directions
		Math	Applies subtraction to decimal values in a sequence; solves word problems using subtraction

Related Academic and Workplace Skills
For *Basic Wiring*

Task	Skill Group	Sub Skill	Description
Unit 17: (Cont.)			
Multiply decimal numbers (A.S. 12)	Foundation Skills	Reading	Draws conclusions from what is read; follows written directions
		Math	Applies multiplication to decimal values; solves word problems using multiplication
Divide decimal numbers (A.S. 13)	Foundation Skills	Reading	Draws conclusions from what is read; follows written directions
		Math	Applies division to decimal values; solves word problems using division
Convert fractions and percentages (A.S. 14)	Foundation Skills	Reading	Follows written directions
		Math	Converts fractions/percentages
Solve percentage problems (A.S. 15)	Foundation Skills	Reading	Draws conclusions from what is read; follows written directions
		Math	Applies computation skills—addition, subtraction, multiplication, and division
Calculate area (A.S. 16)	Foundation Skills	Reading	Follows written directions
		Math	Calculates area for geometric figures

Basic Wiring

Tools, Equipment, and Materials List

- Adjustable wire strippers
- Adjustable wrench
- Ammeter
- Anchors, plastic
- Antioxidant
- Arbor
- Ball peen hammer
- Bar hanger
- Battery
- Belt, back support
- Bolts
- Box clips
- Box with plastic ears
- Boxtins
- Brace
- Breaker index sheet
- Breakers
- Brick wall
- Cable, 12-2G
- Cable clamp, ⅜"
- Carriage lever accessory
- Center punch
- Chime
- Clamp-on ammeter
- Cleaning cloth
- Compression type fitting, ½"
- Concrete block wall
- Concrete chisel
- Conduit bender
- Connectors
- Construction blueprint
- Copper wire, insulated
- Cord connector
- Couplings
- Cutting/crimping tool
- Cutting oil
- Device box
- Die head accessory
- Door bell buttons
- Drill
- Drill bit, ½"
- Drill motor
- Drop chain
- Drop cloth
- Drop light and cord
- Drywall grips
- Duplex receptacle
- Dust mask
- Electrical boxes
- Electrician's hammer
- Electrician's knife
- EMT bender, ½"
- EMT connector, compression-type
- Extension cord
- Fasteners
- Fish tape, steel
- Fish wire
- Fixed appliance, small
- Flat bar
- Flatblade screwdriver
- Folding rule
- Fuses
- Hacksaw
- Hacksaw blade
- Handy box
- Hanger bar
- Header board
- Heat-cool thermostat, subbase
- Heating unit
- Hole saw
- Hook knife
- Hydraulic pipe bender
- Incandescent bulb, 120V
- Insulated gloves
- Insulated wire
- Keyhole saw
- Knockout punch
- Ladder
- level
- Lighting relay, 24-volt
- Light socket
- Lighting switches, low voltage
- Lineman's pliers
- Live disconnect
- Long nose pliers
- Masking tape
- Masonry bit, ¼"
- Megger
- Metal tapping screws
- Mortar

Tools, Equipment, and Materials List

Multimeter
Nails
Needlenose pliers
NM cable
Octagon box
Oil
Oiler
Outlet boxes
Pail
Paint brush
Paneled wall
Pencil
16 penny nails
Phasing tape
Pipe or conduit
Pipe cutter
Pipe reamer
Pipe vise
Plaster rings
Plasterboard
Plasterboard nails
Plasterboard wall
Pliers
Portable fire extinguisher
Portable GFCI
Pouch tools
Power supply, 120 volt
Power threader, stand
Protective gloves
PVC conduit
PVC glue
PVC heater
Reamer
Resistor
Rigid conduit
Romex staples
Safety glasses
Safety switch
SE cable
Set screw fitting, ½″
Sheetmetal screws
Ship auger bit
Shop towel
Single pole switch
Solid insulated conductor
Solvent
Solvent tray
Sponge
Square boxes
Staples
Steel pipe
Step down transformer, 120-24 volt
Step ladder
Stove belt
String
Stud clips
Stud wall
Switch, 3-way
Switch, 4-way
Switch box with ears
Tape
Test leads
Thermostat
Thermostat subbase
Tool carriage accessory
Torpedo level
Touch up paint
Transformer, 16-volt
Trouble light and bulb
Vise
Volt-ohmmeter
Whisk brook
Wire, #10 THHN
Wire brush
Wire connectors
Wire lung
Wire nuts
Wire strippers
Wood scraps
Wood screws
Work board

Basic Wiring

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Glossary

A

Accident — Suddenly occurring, unintentional event that causes injury or property damage

Accuracy — How near the instrument reading is to the actual value

Acquired Immune Deficiency Syndrome (AIDS) — Life threatening bloodborne virus that depresses the cells of the immune system

Addition — Process of totaling two or more numbers to find another number called a sum

Air circuit breaker — Breaker in which all parts operate in air

Aluminum wire — Conductor made of aluminum

American National Standards Institute (ANSI) — Develops standards for electrical equipment and supplies

American Standard Association (ASA) — Develops standards for electrical machinery and equipment

American Wire Gauge (AWG) — A series of specified diameters and thicknesses established as a standard in the United States; also known as Brown and Sharp gauge (B and S gauge)

Ampacity — The current, in amperes, that a conductor can carry continuously under the conditions of use without exceeding its temperature rating

Amperage — Electricity; electrical current flow; electron flow; must be measured at a point within a circuit; measure of the rate of flow of current through a conductor

Amperage rating — Maximum current-carrying capacity of a device

Ampere — Unit of measure for electrical current or intensity of electron flow

Anaphylactic shock — Severe and sometimes fatal reaction to an antigen (as bee venom); characterized by respiratory symptoms, fainting, and itching

Apparent power — Term used to describe the power which "appears" to be consumed in an RC circuit when the power formula P = IE is applied to the circuit

Arbor — Shaft or spindle used to hold revolving cutting tool or the work to be cut

Autotransformer — Transformer with a single winding

B

Bare conductor — A conductor having no covering or electrical insulation

Bender — Tool used to make various angles or bends in conduit

Blade type cartridge fuse — Fuse with flat contact blades on a cylindrical case

Bonding — Permanent joining of metallic parts to form an electrically conductive path that will ensure electrical continuity and the capacity to conduct safely any current likely to be imposed

Bonding jumpers — Pieces of wire or other conductors that connect different metal parts

Bonding jumper circuit — Connections between portions of a conductor in a circuit to maintain required ampacity of the circuit

Bonding jumper equipment — Connections between two or more portions of the equipment grounding conductor

Boxfill — Number of conductors of a certain size permitted in a box; number is based on cubic inches of box

Brick bat — Piece of a brick

Building code — Standards developed to provide for safe building construction practices

C

Cabinet — Enclosure designed either for surface or blush mounting; provided with a frame, mat, or trim in which a swinging door or doors may be hung

Cable — A factory assembly of two or more insulated and uninsulated conductors having an outer sheath of moisture-resistant, flame-retardant, non-metallic material

Cable-tie — Plastic straps with pull-through fasteners for binding together conductors or cables

Calibration — Technique of testing and adjusting an instrument by referencing it to another instrument or device of known accuracy and precision

Cardiopulmonary resuscitation (CPR) — Procedure for restoring normal breathing after cardiac arrest

Carelessness — Failure to think before one acts; failure to pay attention

Channel — Groove formed in materials

Chuck — Device for holding a component of a tool rigid

Circuit — A complete path for current to flow from the source through the load and back to the source

Circuit box — Box where electrical connections are made, usually through circuit breakers

Circuit breaker — Automatic overcurrent device that trips on overloads or shorts and is resetable

Circular mils — The diameter of a conductor in thousandths of inches multiplied times itself

Coaxial cable — Conductor used for carrying communication signals

Color coding — Assigning colors to conductors based on their uses

Combustible — Capable of bursting into flames at temperatures above 100°F

Concentric knockout — Several removable metal rings that allow for entrance of various standard sizes of connectors into a cabinet

Conductor — Material through which electrons flow easily; used to connect components

Conduit — Pipe or tube which holds and protects wires or cables

Connections — Termination points where conductors are joined together

Copper-clad aluminum — Aluminum conductor with an outer coating of copper metallurgically bonded to the aluminum core

Copper wire — Conductor made of copper

Cord — Two or more stranded conductors grouped together in a flexible covering

Coupling — Mechanical device for connecting conduit and cabling

Covered — Conductor encased within material of composition and thickness not recognized by the *National Electrical Code* as electrical insulation

Cross handle — Handle set across a power tool to prevent the tool from turning

Cross sectional area — Area in square inches allowed in a conduit or tubing; area required for conductors in a conduit or tubing

Cube tap — A device that plugs into a receptacle and provides space for connection of two or more attachment plugs

Current — Electron flow through a conductor

Current-limiting overcurrent protective device — Device that, when interrupting current in its current-limiting range, reduces the short-circuit current flowing in the faulted circuit to substantially less than would otherwise flow into the fault

Cutter — Hardened steel device used to cut holes in metal boxes

D

DC — Abbreviation for direct current

Dead front — Removable cover used to prevent exposure of live parts to persons on the operating side of the equipment

Decimal — Fraction with an unwritten denominator of 10 or same power of 10; indicated with a point before the number

Device — Electrical equipment that carries or transfers current but does not use it

Die — Component that backs up cutter on opposite side of metal box

Dielectric materials — Insulating materials capable of accumulating an electrical charge

Digit — Any one of the ten symbols, 0 to 9, by which all numbers can be expressed

Disconnecting means — Device or group of devices, or other means by which circuit conductors can be disconnected from their source of supply

Division — Opposite operation of multiplication

Domains — Molecules that act as small magnets when arranged end-to-end

Drop chain — Short length of small chain used to pull cable or flexible conduit through an enclosed space or wall cavity

Drop cloth — Cloth used to catch falling debris from cutting or chipping work

Dual-element fuse — Fuse that has a thermal cutout element with a time delay that permits momentary harmless inrush currents to flow without having the fuse

Dustproof — So constructed or protected that dust will not interfere with successful operation

Dusttight — So constructed that dust will not enter the enclosing case

E

Eccentric knockout — Knockout that is removed in sections to form larger holes

Edison base plug fuse — Fuse with a base that fits the same sockets as a regular based incandescent bulb

Electrical shock — The sudden stimulation of nerves and muscles caused by the discharge of electricity through the body when the body contacts an energized electrical circuit

Electricity — Invisible energy

Electromagnet — A magnet made by winding a conductor around a metal core with voltage applied

Electron flow — Electrons transferring from one atom to another

Equipment — A general term including material, fittings, devices, appliances, fixtures, apparatus, and the like used as a part of, or in connection with, an electrical installation

Error — How far the measurement is from the actual value

Explosionproof — Capable of containing hot explosive flames within the enclosure to prevent explosions in the surrounding atmosphere

Exposed (as applied to wiring methods) — On or attached to the surface or behind panels designed to allow access

F

Fault current — Current that flows from one conductor to ground or another conductor because of an abnormal connection or arc between the two

Ferrule type cartridge fuse — Fuse with metal caps on a cylindrical case

Fire extinguisher — That which quickly puts out fires or at least smothers flames

First aid — Immediate temporary care given the victim of an accident or sudden illness until the services of a physician can be obtained

First degree burn — Burn affecting only the outer skin layers; characterized by redness and pain

Fish — Establishing a connection between two points so a cable can be installed

Fish tape — Long tape of steel, nylon, or other material used to push or pull a conductor into a raceway

Fish wire — Length of wire with a hook formed in one end to catch materials being installed in a space

Fitting — An accessory, such as a locknut, bushing, or other part of a wiring system, that is intended primarily to perform a mechanical rather than an electrical function

Flammable — Capable of being easily ignited and burning quickly at temperatures below 100°F

Flux lines — Power around a magnet

Formula — A mathematical expression used to find unknowns

Fraction — Part of a whole; represents one or more equal parts of a unit

Fuse — Safety device placed in a circuit; in cases of excessive current, it melts, thus opening the circuit

G

Ground — Electrical point or any good conductor that is connected to a common chassis with zero relative voltage; usually conductors are connected to the earth

Grounded — Electrical connection to an object that conducts electrical current to the earth

Grounded conductor — A system or circuit that is intentionally grounded (connected to the earth or some conductor that serves in place of the earth)

Grounding conductor — Conductor used to connect equipment or the grounded circuit of a wiring system to a grounding electrode or electrodes

Grounding electrode conductor — Conductor used to connect the grounding electrode to the equipment grounding conductor or to the grounded conductor of the circuit at the service equipment or at the source of a separately derived system

Ground fault — Accidental connection between an electrical circuit or equipment and the earth or some conducting body that serves in place of the earth

Ground fault circuit interrupter — Breaker or device designed to protect individuals and equipment by deenergizing or tripping a circuit when current to ground reaches 0.005 amperes

H

Hazard — Potential source of danger

Hazardous material — Any cancer-causing, corrosive, toxic, irritant, sensitizer, or material that has, or has the potential for, damaging effects on specific body organs

Heat detectors — A fire warning device commonly used in a residence; available in two types; fixed or rate-of-rise temperature detectors

Heat shrink — Nonconductive material placed around a conductor for insulation; shrinks when heated

Heel -- To apply pressure to the bottom of a straight or extension ladder to prevent it from slipping or sliding sideways while in use

Henry — Amount of inductance into a conductor when the current changes at the rate of one ampere per second

Hepatitis — Infectious disease marked by inflammation of the liver

Hertz — One complete positive to negative cycle in an alternating current circuit

Hydraulic — A system where the main operation of equipment is operated by fluids

Hydraulic oil — Specially formulated oil for hydraulic pumps

Hygiene — Conditions or practices of cleanliness conducive to health

I

Insulated — Conductor encased within material of composition and thickness recognized by the *National Electrical Code* as electrical insulation

Insulation — Nonconductive material that prevents leakage of electricity from a conductor and protects against accidental contact

Interrupting rating — Maximum available short-circuit current that an overcurrent device can safely interrupt without danger to itself

J

Joint Industry Conference (JIC) boxes — Boxes or enclosures made to Joint Industry Conference Standards for such uses as junction boxes and housing terminal blocks

Junction boxes — Enclosures designed for conduit or cable entrances to enclose the conductor splices and taps

Jurisdiction — Power, right, or authority to interpret the law (code)

K

Knockout (KO) — Partially cut out piece of metal or plastic that can be forced out when a hole is needed

Knockout punch — Device used to make openings for conduit in metal enclosers

L

Lath and plaster — Old method for covering interior walls; small strips of wood spaced evenly over studs to support and hold plaster

Liter — Metric unit used to measure capacity

Live circuit — Circuit with voltage applied

M

Magnetism — Property possessed by certain materials which exerts a mechanical force on other magnetic materials, and which can cause induced voltage in conductors when relative movement is present

Mandatory enforcement — Governmental authority to demand compliance with the *National Electrical Code* requirements for electrical installations

Material safety data sheet (MSDS) — Form that lists and explains each of the hazardous materials that an employee works with so that the employee can safely use the material and respond to emergency situations

Meter — Metric unit used to measure length

Mil — One thousandth of an inch

Momentary contact switch — A switch that is closed or opened only while the operator touches it

Multimeter — Instrument capable of measuring a "multiple" of values

Multi-outlet assembly — A type of surface of flush raceway designed to hold conductors and receptacles

Multiplication — Abbreviated process of adding a number to itself a specified number of times

N

National Electrical Code (NEC) — A publication developed by the National Fire Protection Association to help safeguard persons and property from hazards arising from the use of electricity; contains electrical specifications endorsed by NFPA and ANSI

National Electrical Manufacturers Association (NEMA) — Develops electrical equipment standards

National Fire Protection Association (NFPA) — Develops and publishes fire and industrial safety standards

NEMA Type 1 — General purpose enclosure for use indoors under usual service conditions

NEMA Type 2 — Driptight enclosure used indoors to exclude falling moisture and dirt

NEMA Type 3 — Weather resistant (weatherproof) and suitable for indoor and outdoor use; will exclude falling dirt, light liquid splashing, rain, snow, sleet, and windblown dust

NEMA Type 4 — Watertight and dustproof enclosures suitable for areas where a great amount of splashing occurs, such as hose down area

NEMA Type 5 — Dust-tight enclosure not suitable for use around water

NEMA Type 12 — Industrial use enclosure designed to exclude oil, coolant, flying dust and lint, and falling dirt

NEMA enclosures — Electrical enclosures specifically designed to standards for use in specific locations and various conditions such as indoor, outdoor, dusty, corrosive, wet, and explosive conditions

O

Occupation — The vocation or activity at which a person works

Occupational Safety and Health Administration (OSHA) — Federal legislation designed to ensure safe and healthful working condition for employees

Ohm — Unit of measure for electrical resistance

Oil circuit breaker — Load interrupter in which the interrupting contacts operate submerged in transformer oil

Opposition — Resistance to current flow

Outlet boxes — Electrical boxes designed for the mounting of receptacles, switches, light fixtures, or other devices

Overcurrent protection — Weak link in the circuit that limits the amperage to a specified amount

Overload — Larger than normal current flowing within the normal current path

P

Parallax correction — Viewing analog VOM from directly above the needle to avoid the possibility of wrong readings due to depth perception

Parallel circuit — A circuit which provides more than one path for current to flow

Percent — One part in a hundred; reckoned on the basis of a whole divided into one hundred parts

Pinch point — Any opening that may close and bind a finger or hand

Pipe chase — Usually a vertical space between two floors, dedicated for the running of pipes and conduits between floors

Plasterboard (Sheetrock®) — Flat sheet used in construction as a wall covering; it has an outer covering of felt sandwiching a gypsum plaster core

Pneumatics — A system by which equipment is powered by air

Polarity — When magnetism leaves a body north and enters south

Polyvinyl chloride (PVC) — Plastic pipe

Power — Rate of consumption of energy

Precision — Instrument consistency

Premises wiring (system) — That interior and exterior wiring, including power, lighting, control, and signal circuit wiring together with all of its associated hardware, fittings, and wiring devices, both permanently and temporarily installed which extends from the load end of the service drop, or load end of the service lateral conductors to the outlet(s). Such wiring does not include wiring internal to appliances, fixtures, motors, controllers, motor control centers, and similar equipment

Primary — Transformer winding that receives power from the source

Print — Industrial blueprint; industrial wiring diagram

Proportional — Being relatively equal in size or quantity

Pull-push solenoid — Solenoid with two electromagnetic circuits that will pull or push a plunger depending on which magnet has current applied to it

R

Rainproof — So constructed, protected, or treated as to prevent rain from interfering with successful operation

Raintight — So constructed or protected that exposure to a beating rain will not result in the entrance of water

Ram — Device used to transfer hydraulic pressure to a mechanical device

Ratio — Relationship in quantity, amount, or size between two or more things

Relay — Electromagnetic device for remote or automatic control

Resistance — Opposition to electrical current flow; measured in units of ohms; must be measured from one point to another; opposition to electron flow in a conductor or circuit

Resolution — How well an instrument will indicate a small change in the measured value

S

Safety — Freedom from danger, risk, or injury

Secondary — Transformer winding that receives power from the primary winding

Second-degree burn — Burn penetrating beneath the superficial skin layers; characterized by swelling and blisters

Selective coordination — The use of interrupting devices sized and installed so that the one nearest a fault or overload will open before any of the larger upstream devices open

Series circuit — A circuit that provides more than one path for current flow

Series-parallel circuit — A circuit that contains some components in series and some in parallel

Shock — The sudden stimulation of the nerves and muscles caused by the discharge of electricity through the body; shock can occur if the body contacts an electrical circuit and can cause serious burns and muscle damage

Short circuit — Larger than normal current flowing outside the normal current path

Single element fuse — Fuse that contains only one element and is not designed to carry an overload

Single phase — One AC power source

Smoke detector — A fire warning device commonly used in a residence that is available in two types: photoelectric or ionization

Snap ring — Metal ring which fastens around or in a shaft to keep other parts stationary

Solenoid — Electromagnetic cylinder that will move an iron plunger when current is applied

Spaghetti — Nonconductive material placed around a conductor for insulation; does not shrink

Stud finder — Compass type tool which uses a magnet to locate nails and thus indicate stud locations

Subtraction — Opposite operation of addition

T

Telephone system — A personal communication system installed in the home to provide outside conversation with the world

Thermostat — A device that senses temperature variations from a set point and, in turn, acts to control a circuit

Third-degree burn — Burn that destroys all skin layers and underlying tissue; characterized by white, leathery appearance and lack of pain

Time current curve — Plotted curve showing how long a fuse or breaker will carry an overload before opening the circuit

Transformer — An electrical device used to step up or step down a primary voltage to a desired secondary voltage

True power — The power that a device is actually using

Type letter — Identification accepted by the trade in referring to the particular types of insulations

Type "S" plug fuse — Fuse with special size limiting characteristics for each amperage range

U

Underfloor crawl space — Working space underneath the house

Underwriters Laboratories (UL) — Test equipment and list items for use in specified situation

V

Volt — Unit of measure for electrical pressure

Voltage — Electromotive force (emf); force that drives electricity through conductors; must be measured across, between, or be referenced to a second point; the measurement of the potential difference between conductors in a circuit

Voltage drop — Reduction in circuit potential difference due to resistance

Voltage rating — Maximum voltage at which a device is designed to operate

W

Watt — Unit of measure of the power of an electric circuit

Waveform — The shape of a wave as a function of time, distance, and amplitude

Whole number — Any of the natural numbers, both positive and negative, that represents a complete item

Windings — Conductors coiled around a metal core in a transformer or motor

Wire lug — Metal connector crimped or soldered to a conductor; allows conductor to be fastened with a screw or bolt

Occupational Introduction
Unit 1

Objective Sheet

Unit Objective

After completing this unit, the student should be able to discuss the occupational outlook of the electrical field. The student should demonstrate this competency by completing the assignment sheets and scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Define *NEC* and *occupation*.
2. State the major purposes of the *NEC*.
3. List areas the *NEC* is intended to cover.
4. List areas the *NEC* is not intended to cover.
5. List job responsibilities of electrical workers.
6. Select from a list desirable physical abilities of electrical workers.
7. List employment opportunities in the electrical field.
8. List occupational hazards related to electrical work.
9. Match electrical trade organizations with their descriptions.
10. Complete statements about *Code* compliance.
11. Interview an electrical worker. (Assignment Sheet 1)
12. Compare employment opportunities in the electrical field. (Assignment Sheet 2)

Occupational Introduction
Unit 1

Suggested Activities

Instructional Plan

Preparation

1. Read the unit carefully and plan for instruction. Study the specific objectives to determine the order in which you will present them.

2. Review Teaching Suggestions section that follows. Plan for classroom activities.

3. Plan your presentation to take advantage of student learning styles and to accommodate special needs students.

4. Develop teaching plan. Adjust for different learning styles.

5. Make copies of Unit Evaluation Form.

Delivery and Application

6. Provide students with unit of instruction.

7. Discuss unit and specific objectives.

8. Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic skills when applicable.

9. Discuss the assignment sheets and schedule due dates. Review criteria for evaluation of these activities.

Evaluation

10. Discuss the use of the Unit Evaluation Form with students. Discuss the rating scale that will be used for student evaluation.

11. Make copies of the written test. Add or modify test items as needed.

12. Give written test.

13. Compile assignment sheet ratings and written test scores on the Unit Evaluation Form. Include any additional assignments.

14. Meet individually with students to evaluate their progress throughout this unit of instruction, and indicate to them possible areas of improvement.

Suggested Activities

Teaching Suggestions

Note: Skill areas appearing in boldface type in the Teaching Suggestions refer to the academic and workplace skills identified by the American Society for Training and Development (ASTD) and the U.S. Department of Labor. These have been adapted by MAVCC.

1. Invite local contractors, electricians, and inspectors to class to discuss employment opportunities and their respective job responsibilities. Skill area: **Listening**

2. Visit local construction sites. Have students write summary reports of their observations. Skill areas: **Writing, learning to learn**

3. Visit a local company or manufacturer that employs electrical maintenance workers. Before the visit, have the students prepare questions that they want to ask. Skill areas: **Writing, listening, learning to learn**

4. Upon completion of Assignment Sheet 1, have the students share the information they obtained during their interviews with electrical workers. Skill areas: **Writing, public speaking**

5. Upon completion of Assignment Sheet 2, have students compare employment opportunities and compile a list of local employment opportunities. Skill areas: **Writing, teamwork, public speaking**

Resources Used in Developing This Unit

1. *Electricity Occupations Curriculum Guide.* Springfield, IL: Illinois Office of Education/Division of Vocational and Technical Education.

2. Taylor, Mark. *Residential Wiring.* Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1983.

Suggested Supplement Resource

1. Software — *Introduction to Electricity.* Shopware Educational Systems Department KL-4, 101 Hill Road, Aberdeen, WA 98520-7302.

Suggested Activities

Instructions for Evaluating Student Performance

Assignment Sheets—Be sure the student understands the criteria on which the evaluation is based. Assign a point value to each criterion and convert the total points to a percentage for grading.

Job Sheets—Be sure the student understands the criteria on which the evaluation is based. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in either the teacher or student edition. Then observe the student performing the procedure. Rate both process and product.

> Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily achieved the step(s) for each checkpoint area. If the student is unable to correctly complete the procedure, have the student review the materials and try again.
>
> Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria which have been provided as part of the job sheet. Complete the rating by assigning a point value to each criterion and by converting the point total to a percentage for grading. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) which best fits your program needs.

Option A

4 - Skilled—Can perform job with no additional training.
3 - Moderately skilled—Has performed job during training program; limited additional training may be required.
2 - Limited skill—Has performed job during training program; additional training is required to develop skill.
1 - Unskilled—Is familiar with process, but is unable to perform job.

Option B

Yes—Can perform job with no additional training.

No—Is unable to perform job satisfactorily.

Occupational Introduction
Unit 1

Answers to Written Test

1. a. **NEC** — *National Electrical Code*; a publication developed by the National Fire Protection Association to help safeguard persons and property from hazards arising from the use of electricity
   b. **Occupation** — The vocation or activity at which a person works

2. Answer should include any three of the following:

   a. The *NEC* sets the minimum standards for electrical work in general and specific instances.
   b. The purpose of the *NEC* is the "practical safeguarding of persons and property from hazards arising from the use of electricity."
   c. The *NEC* is considered necessary for safety; compliance with the *Code* will result in an installation that is free from hazard; this does not guarantee efficiency or adequacy for future expansion.
   d. The *NEC* is not intended to be a design manual or an instructional manual for untrained individuals.
   e. The *NEC* protects the consumer from dangerous installations of electrical wiring and serves as a means for testing and protecting those who install said wiring.
   f. The *NEC* is considered to be suitable for mandatory enforcement by government bodies having legal jurisdiction.

3. Answer should include any three of the following:

   a. Installations of electric conductors and equipment in and on public and private buildings
   b. Installations of conductors and equipment that connect to the supply of electricity
   c. Installations of outside conductors and equipment
   d. Installation of optical fiber cable

4. Answer should include any three of the following:

   a. Installations in ships, watercraft, railway rolling stock, aircraft, and automotive vehicles
   b. Installations underground in mines and self-propelled mobile surface mining equipment and its trailing cables
   c. Installation of railways used exclusively for operation of rolling stock or exclusively for signaling and communications
   d. Installation of communication equipment under control of communication utilities
   e. Installations under the exclusive control of electrical utilities

Answers to Written Test

5. Answer should include any six of the following:

   a. Install all types of electrical equipment.
   b. Hang electrical fixtures.
   c. Install switching and power outlets.
   d. Install appliances.
   e. Design electrical systems.
   f. Troubleshoot and repair defective systems.
   g. Practice good work ethic; be dependable and honest.
   h. Be courteous to customers and co-workers.
   i. Communicate effectively with people.
   j. Practice good personal hygiene.
   k. Participate in trade organizations.

6. b, d, e, f

7. Answer should include the following in any order:

   a. Electrician's helper
   b. Installer
   c. Apprentice
   d. Journeyman
   e. Master electrician or contractor
   f. Maintenance electrician
   g. Electrical parts/equipment salesperson
   h. Inspector

8. Answer should include the following in any order:

   a. Death
   b. Burns
   c. Broken bones or bruises
   d. Sprains or muscle tear

9. a. 3
   b. 5
   c. 1
   d. 4
   e. 2

10. a. Obligated
    b. Lives
    c. License
    d. Livelihood

Occupational Introduction
Unit 1

Written Test

Name ______________________________ Score ____________

1. Define *NEC* and *occupation*.

   a. *NEC* — ______________________________

   b. Occupation — ______________________________

2. State three major purposes of the *NEC*.

   a. ______________________________

   b. ______________________________

   c. ______________________________

Written Test

3. List three areas the *NEC* is intended to cover.

   a. ______________________________

   ____

   b. ______________________________

   ____

   c. ______________________________

   ____

4. List three areas the *NEC* is NOT intended to cover.

   a. ______________________________

   ____

   b. ______________________________

   ____

   c. ______________________________

   ____

5. List six job responsibilities of electrical workers.

   a. ______________________________

   b. ______________________________

   c. ______________________________

   d. ______________________________

   e. ______________________________

   f. ______________________________

Written Test

6. Select from the following list desirable physical abilities of electrical workers. Write an "X" in the blank before each correct statement.

______a. Ability to lift at least 100 pounds

______b. Ability to work with hands in a skillful manner

______c. Ability to see perfectly

______d. Ability to distinguish colors

______e. Ability to work in confined areas such as crawl spaces and attics

______f. Ability to work on ladders and scaffolds

7. List eight employment opportunities in the electrical field.

a. ____

b. ____

c. ____

d. ____

e. ____

f. ____

g. ____

h. ____

8. Describe four occupational hazards related to electrical work.

a. ____

____

b. ____

____

c. ____

____

d. ____

____

Written Test

9. Match electrical trade organizations with their descriptions. Write the correct numbers in the blanks.

_______a. An organization of independent electrical contractors or "merit shop" contractors: provides training for the employees of its members

_______b. An organization of electrical contractors that employ primarily IBEW electricians and apprentices

_______c. An organization of electrical contractors that employ nonunion personnel

_______d. An organization of general contractors in the construction industry: provides training to employees of its members in all construction trade areas

_______e. A trade union of workers engaged in electrical installations and maintenance: provides training and placement for its members

1. IEC (Independent Electrical Contractors)
2. IBEW (International Brotherhood of Electrical Workers)
3. AIECA (American Independent Electrical Contractors Association)
4. AGC (Associated General Contractors)
5. NECA (National Electrical Contractors Association)

10. Complete statements about *Code* compliance. Circle the correct word.

a. The electrical contractor and journeyman electrician are (obligated, urged) to comply with local, state, and national codes.

b. Failure to comply could result in the loss of property and (equipment, lives).

c. Failure to comply can result in the revocation of (title, license) or permits.

d. Failure to comply can result in the loss of (livelihood, membership).

***Permission to duplicate this test is granted.**

Occupational Introduction
Unit 1

Unit Evaluation Form

Student Name ______________________ Unit Rating __________

Assignment Sheet 1—Interview an Electrical Worker Rating ______

Comments: ____

____

Assignment Sheet 2—Compare Employment Opportunities in the Electrical Field Rating ______

Comments: ____

____

Written Test Scores

Pretest ______ Posttest ______ Other ______

Other ____

____

Teacher Signature ______________________ Date __________

Student Signature ______________________ Date __________

***Permission to duplicate this form is granted.**

Occupational Introduction
Unit 1

Information Sheet

1. **Terms and definitions**

   a. ***National Electrical Code (NEC)*** — A publication developed by the National Fire Protection Association to help safeguard persons and property from hazards arising from the use of electricity

   Note: The *National Electrical Code* is updated every 3 years.

   b. ***Occupation*** — The vocation or activity at which a person works

2. **Major purposes of the *NEC***

   a. The *NEC* sets the minimum standards for electrical work in general and specific instances.

   Note: Any person employed in the electrical field should obtain a copy of the *NEC* and know how to use it. The *NEC* is commonly referred to as "the electrician's bible."

   b. The purpose of the *NEC* is the "practical safeguarding of persons and property from hazards arising from the use of electricity."

   c. The *NEC* is considered necessary for safety; compliance with the *Code* will result in an installation that is free from hazard; this does not guarantee efficiency or adequacy for future expansion.

   d. The *NEC* is not intended to be a design manual or an instructional manual for untrained individuals.

   e. The *NEC* protects the consumer from dangerous installations of electrical wiring and serves as a means for testing and protecting those who install said wiring.

   f. The *NEC* is considered to be suitable for mandatory enforcement by government bodies having legal jurisdiction.

3. **Areas the *NEC* is intended to cover**

   a. Installations of electric conductors and equipment in and on public and private buildings

   b. Installations of conductors and equipment that connect to the supply of electricity

   c. Installations of outside conductors and equipment

   d. Installation of optical fiber cable

Information Sheet

4. Areas the *NEC* is not intended to cover

a. Installations in ships, watercraft, railway rolling stock, aircraft, and automotive vehicles

b. Installations underground in mines and self-propelled mobile surface mining equipment and its trailing cables

c. Installation of railways used exclusively for operation of rolling stock or exclusively for signaling and communications

d. Installation of communication equipment under control of communication utilities

e. Installations under the exclusive control of electrical utilities

5. Job responsibilities of electrical workers

Note: The student entering the electrical field should be aware of the need for continued study. As industry changes, new methods and techniques will become industry standards. Electrical workers are expected to use and interpret the *National Electrical Code*, as well as perform complex mathematical calculations.

a. Install all types of electrical equipment.

b. Hang electrical fixtures.

c. Install switching and power outlets.

d. Install appliances.

e. Design electrical systems.

f. Troubleshoot and repair defective systems.

g. Practice good work ethic; be dependable and honest.

h. Be courteous to customers and co-workers.

i. Communicate effectively with people.

j. Practice good personal hygiene.

k. Participate in trade organizations.

Examples: IBEW, AIECA, AGC, NECA

Information Sheet

6. **Desirable physical abilities of electrical workers**

    a. Ability to distinguish colors

    Note: Many components and conductors commonly used in the electrical field are color coded. It is imperative that workers are able to distinguish colors readily.

    b. Ability to lift heavy objects

    c. Ability to work in confined areas such as crawl spaces and attics

    d. Ability to work on ladders and scaffolds

    e. Ability to work with hands in a skillful manner

7. Employment opportunities in the electrical field

    a. **Electrician's helper** — Person who assists an electrician

    b. **Installer** — Person who installs electrical equipment under the supervision of a journeyman

    c. **Apprentice** — Helper enrolled in a formal training program

    d. **Journeyman** — Electrician working under the supervision of a contractor

    e. **Master electrician or contractor** — Person licensed to enter contractual agreements involving electrical work

    f. **Maintenance electrician** — Person who maintains and repairs electrical equipment and processes

    g. **Electrical parts/equipment salesperson** — Person who works for an electrical wholesale parts outlet

    h. **Inspector** — Person who represents the authority having jurisdiction over electrical installations

Information Sheet

8. **Occupational hazards related to electrical work**

Note: The electrical worker is a highly respected trade worker. The jobs that are performed are generally in areas or surroundings more desirable than those in other trades. However, demanding conditions do occur. Inclement weather is also a factor.

a. **Death** — Careless and unsafe work habits can result in fatal accidents

b. **Burns** — Accidental shorts or faults occasionally blow slag or molten metal, which can burn

c. **Broken bones or bruises** — Working on ladders or in other hazardous construction situations can result in falls

d. **Sprains or muscle tear** — Many pieces of electrical equipment are heavy and bulky; often help must be summoned to avoid injury to the worker.

9. **Electrical trade organizations**

Note: There are many trade organizations available to those employed in the electrical industry. These organizations serve a vital function to the electrician and electrical contractor. They serve to provide updates on the latest equipment and methods as well as new *Code* changes. These organizations play a vital role in effecting legislation that affects the industry. As a student it is important to participate in your local student vocational organization, this experience will provide you with an insight into the workings of a trade organization.

a. **IEC** (Independent Electrical Contractors) — An organization of electrical contractors that employ nonunion personnel

b. **IBEW** (International Brotherhood of Electrical Workers) — A trade union of workers engaged in electrical installations and maintenance; provides training and placement for its members

c. **AIECA** (American Independent Electrical Contractors Association) — An organization of independent electrical contractors or "merit shop" contractors; provides training for the employees of its members

d. **AGC** (Associated General Contractors) — An organization of general contractors in the construction industry; provides training to employees of its members in all construction trade areas

e. **NECA** (National Electrical Contractors Association) — An organization of electrical contractors that employ primarily IBEW electricians and apprentices

Information Sheet

10. ***Code* compliance**

   a. The electrical contractor and journeyman electrician are obligated to comply with local, state, and national codes.

   b. Failure to comply could result in the loss of property and lives.

   c. Failure to comply can result in the revocation of license or permits.

   d. Failure to comply can result in the loss of livelihood.

Occupational Introduction
Unit 1

Assignment Sheet 1—Interview an Electrical Worker

Name ______________________ Overall Rating __________

Evaluation criteria	Rating
Interview set up and process	_____
Four of four Assignment Sheet 1 questions answered	_____
Preparation for class discussion	_____

Directions: Locate and interview an electrical worker in your area. Answer the following questions based on your interview. Be prepared to discuss the interview in class.

A. What is the occupation of the worker being interviewed, and what are the job responsibilities?

B. What type of training is needed?

C. What kind of salary can be expected?

D. What is the future outlook for this occupation?

Occupational Introduction
Unit 1

Assignment Sheet 2—Compare Employment Opportunities in the Electrical Field

Name ______________________________ Overall Rating __________

Evaluation criteria	Rating
Appropriateness of advertisements collected	
Neatness, appearance, and grammatical correctness of paragraph	
Preparation for class discussion	

Directions: Collect four classified advertisements from your local or area newspaper relating to employment opportunities in the electrical field. Compare each opportunity and determine which one would best suit your interests and needs. Write a paragraph on why you chose that occupation. Be prepared to discuss your paragraph in class.

General Safety and First Aid
Unit 2

Objective Sheet

Unit Objective

After completing this unit, the student should be able to identify hazardous job conditions, practice good work and shop safety, and perform basic first aid. The student should demonstrate these competencies by completing the assignment and job sheets and scoring a minimum of 100 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to general safety with their correct definitions.
2. Complete guidelines for dressing safely on the job.
3. Select true general job and shop safety rules.
4. List shop conditions that should be reported.
5. Select words to complete statements about OSHA's role in workplace health and safety.
6. Select true statements about hazardous cleaners and lubricants.
7. Select words to complete statements about the storage of hazardous materials.
8. Distinguish between two common hazardous materials found at the job site.
9. Select words to complete the purposes of material safety data sheets (MSDS).
10. Describe ways hazardous materials can enter the body.
11. Match colors of the safety color code with their uses.
12. Match safety tags with their color coding.
13. List the components of the fire triangle.
14. Match types of fires with their classifications.
15. Complete fire extinguisher general operating instructions that follow the letters P-A-S-S.

Objective Sheet

16. Match general types of fire extinguishers with their uses.
17. Match causes of back injuries with their contributing factors.
18. Select words to complete guidelines for lifting and moving items safely.
19. List guidelines for preventing slips, trips, and falls.
20. Select words to complete rules for using ladders safely.
21. Select from a list safety guidelines for using scaffolds.
22. Select from a list safety guidelines for using power lifts.
23. List in order the general steps for handling any emergency situation.
24. Complete general guidelines for first-aid emergencies.
25. Describe basic first-aid procedures for various emergency situations.
26. Interpret a material safety data sheet. (Assignment Sheet 1)
27. Draw a layout of your school shop and apply the safety color code. (Assignment Sheet 2)
28. Interpret portable fire extinguisher symbols. (Assignment Sheet 3)
29. Identify and correct safety violations. (Assignment Sheet 4)
30. Operate a fire extinguisher. (Job Sheet 1)
31. Lift a heavy object properly. (Job Sheet 2)
32. Place and climb a ladder safely. (Job Sheet 3)

General Safety and First Aid
Unit 2

Suggested Activities

Instructional Plan

Preparation

1. Read the unit carefully and plan for instruction. Study the specific objectives to determine the order in which you will present them.

2. Review Teaching Suggestions section that follows. Plan for classroom activities.

3. Plan your presentation to take advantage of student learning styles and to accommodate special needs students.

4. Make transparencies from the transparency masters included with this unit. The masters appear in the teacher guide only and are intended to be used with the following objectives:

   TM 1—Maintain Tools (Objective 3)
   TM 2—Safety Tag Color Codes (Objective 12)
   TM 3—Classes of Fuel or Fires (Objective 14)
   TM 4—Extinguisher Markings (Objective 14)
   TM 5—Extinguisher Picture Symbols (Objective 14)
   TM 6—How to Lift Safely (Objective 18)
   TM 7—How to Lift Safely (Continued)
   TM 8—Safety Practices for Step Ladders (Objective 20)
   TM 9—Safe Ladder Angle (Objective 20)
   TM 10—Scaffold Construction (Objective 21)

5. Obtain films, videotapes, and other resources to supplement instruction of this unit. See ordering information in the Suggested Supplemental Resources section that follows.

6. Develop teaching plan. Adjust for different learning styles.

7. Make copies of Unit Evaluation Form.

Delivery and Application

8. Provide students with unit of instruction.

9. Discuss unit and specific objectives.

10. Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills where applicable.

Suggested Activities

11. Discuss the assignment sheets and schedule due dates. Review criteria for evaluation of these activities.

12. Discuss and demonstrate the job sheets. Review evaluation criteria for each. Schedule performance dates.

Evaluation

13. Discuss the use of the Unit Evaluation Form with students. Select and discuss the rating scale that will be used for student evaluation.

14. Make copies of the written test. Add or modify test questions as needed.

15. Give written test.

16. Compile assignment and job sheet ratings and written test scores on the Unit Evaluation Form. Include any additional assignments.

17. Reteach and retest as required.

Teaching Suggestions

Note: Skill areas appearing in boldface type in the Teaching Suggestions refer to the academic and workplace skills identified by the American Society for Training and Development (ASTD) and the U.S. Department of Labor. These have been adapted by MAVCC.

1. Have a Red Cross representative demonstrate CPR and first-aid techniques to the class. Skill areas: **Observing the application of scientific principles, listening**

2. Have a local fire marshal or fire extinguisher company representative demonstrate the proper use of fire extinguishers. Skill areas: **Observing the application of scientific principles, listening**

3. Discuss the fire evacuation plan for the classroom and shop, including evacuation routes and fire exits, as well as after-emergency evacuation routes and procedures for tornado alerts. Skill area: **Listening**

4. Have a local OSHA inspector talk to the class about OSHA rules and regulations. Skill area: **Listening**

5. Invite a safety representative from local industry to talk to the class about safety practices and procedures. Skill area: **Listening**

6. Discuss the Good Samaritan Act and your state's policy on using lifesaving techniques in emergency situations. Skill area: **Listening**

7. Show students examples of safety signs and tags.

8. Make copies of Teacher Supplement 1 to distribute to the students before discussing Objective 5. Skill area: **Reading**

Suggested Activities

Resources Used in Developing This Unit

1. *ABC's of Fire Protection.* Belleville, NJ: Walter Kidde & Co., Inc.
2. *Safety in Electrical Maintenance.* Rockville, MD: NUS Training Corporation, a Halliburton Company.
3. Taylor, Mark. *Residential Wiring.* Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1983.
4. Walker, Susan S. *Introduction to Hospitality and Tourism,* "Unit 3—Basic Workplace Safety and First-Aid Skills." Mid America Vocational Curriculum Consortium Inc., 1993.

Suggested Supplemental Resources

Publications

1. *American Red Cross: Adult CPR.* American National Red Cross.

   Note: Contact your local Red Cross chapter to order the most recent edition of this publication.
2. *The American Red Cross, Standard First Aid and Personal Safety.* Garden city, NY: Doubleday and Co., Inc., 1978.
3. *Fire Extinguisher: Classifications and Uses.* NIMCO, P.O. Box 9, Calhoun, KY 42327. Phone (800) 962-6662.
4. *MSDS Pocket Dictionary.* Schenectady, New York: Genium Publishing Corporation, 1989.
5. *OSHA Safety and Health Standards.* Washington, DC: U.S. Department of Labor, Occupational Safety, and Health Administration.

Videotapes

1. *R.I.P. Harry Speaks* (20 minutes)
2. *Your Guardian Angel* (15 minutes)

   Note: Order from International Film Bureau, Inc., 332 S. Michigan Avenue, Chicago, Il 60604-4382.

Suggested Activities

3. The R.E.A.C.T. series of first-aid and safety color videos is an MTI release produced by Charles S. Maccrone Productions, Inc., but is available in ½-inch VHS format from Coronet Films, 65 E. South Water Street, Chicago, Illinois 60601; phone 1-800-621-2131. Titles in this series are listed and described below.

   Note: Oklahoma teachers may order this series of videos from the Instructional Media Center of the Oklahoma Department of Vocational and Technical Education. All other teachers must order the videos from the address above.

   — *Accident Prvention and Safety*, 13 min., copyright 1984.

   In this video, a machine-shop foreman and a worker review the machine safety precautions. Home safety hints for accident prevent are also outlined.

   — *Care for a Choking Victim Who is Unconscious*, 8 min., copyright 1984.

   In this video, a rescuer treats an unconscious victim in a park.

   — *First Aid for Injuries to Bones, Muscles, and Joints*, 10 min., copyright 1984.

   This program demonstrates how to care for dislocations, fractures, sprains, and strains.

   — *Mouth-to-Mouth Breathing*, 11 min., copyright 1984.

   In this program, rescuers demonstrate the mouth-to-mouth breathing techniques in a variety of situations including the case of a woman who collapses on a tennis court.

   — *Respiratory Emergencies*, 13 min., copyright 1984.

   This program dramatizes what to do when breathing is stopped or impaired, and explains the causes of respiratory failure. It also shows artificial respiration techniques and first aid for swallowed objects and choking.

4. *Slips, Trips, and Falls*, ½" VHS, color, 10 min., copyright 1983, Cornet Films, produced by Film Communicators.

   Note: Oklahoma teachers may order this series of videos from the Instructional Media Center of the Oklahoma Department of Vocational and Technical Education. All other teachers must order the video from the address for Coronet films, which is listed above with the R.E.A.C.T. series.

   This video presents a humorous safety program narrated with Irish humor by Murphy, creator of "Murphy's Law"—which states that if anything can go wrong, it will.

Suggested Activities

Instructions for Evaluating Student Performance

Assignment Sheets—Be sure the student understands the criteria on which the evaluation is based. Assign a point value to each criterion and convert the total points to a percentage for grading.

Job Sheets—Be sure the student understands the criteria on which the evaluation is based. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in either the teacher or student edition. Then observe the student performing the procedure. Rate both process and product.

> Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily achieved the step(s) for each checkpoint area. If the student is unable to correctly complete the procedure, have the student review the materials and try again.
>
> Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria which have been provided as part of the job sheet. Complete the rating by assigning a point value to each criterion and by converting the point total to a percentage for grading. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) which best fits your program needs.

Option A

4 - Skilled—Can perform job with no additional training.
3 - Moderately skilled—Has performed job during training program; limited additional training may be required.
2 - Limited skill—Has performed job during training program; additional training is required to develop skill.
1 - Unskilled—Is familiar with process, but is unable to perform job.

Option B

Yes—Can perform job with no additional training.

No—Is unable to perform job satisfactorily.

General Safety and First Aid
Unit 2

Answers to Assignment Sheets

Assignment Sheet 1

MSDS—Gel Graffiti®

A. An engine degreaser
B. Ethanol
C. Opaque white gel
D. 77
E. Carbon dioxide and foam
F. Container may rupture
G. 50 ppm
H. Yes. Chlorinated hydrocarbon has produced cancer in animal studies
I. Inhalation
J. Headaches, dizziness, irritation, burning eyes, nausea, asphyxia, and possible chemical pneumonitis if aspirated into lungs
K. The vicitm should NOT be induced to vomit
L. Heat, sparks, welding arc, open flames
M. Strong oxidizing agents
N. Incinerate or landfill according to state, local, or federal regulations; should not be flushed to sewer
O. Safety glasses, neoprene gloves, and adequate ventilation
P. Wash with soap and water before handling food

Assignment Sheet 2—Evaluated with Assignment Sheet 2 criteria.

Assignment Sheet 3—Student performance should be evaluated according to the criteria listed on the assignment sheet. Content of each item in the exercise may be evaluated using the following suggestions as guides.

A.
  1. f
  2. b
  3. d
  4. a
  5. e
  6. c

B.
  1. B; red
  2. A; green
  3. D; yellow
  4. C; blue

C.
  1. Pull pin.
  2. Aim nozzle at base of fire.
  3. Squeeze handle.
  4. Sweep nozzle.

Answers to Assignment Sheets

Assignment Sheet 4

A.
1. Red warning tag was removed from drill
2. Did not report stripped wire on drill to instructor
3. Put drill with other tools
4. Was going to try to fix drill cord with electrical tape
5. Afternoon student did not check condition of drill before use
6. Water on floor was ignored

B.
1. John should have left red warning tag on drill.

2-3. He should have reported the damaged tool to the instructor and it should have been removed from other tools until fixed.

4. Repair of tools should be handled by instructor or under the instructor's supervision.
5. Jim should have checked the condition of the drill prior to plugging it in.
6. The water spill should have been cleaned up. If water was still running as a result of plumbing work, Jim should have reported condition to the instructor and been assigned another job.

General Safety and First Aid
Unit 2

Answers to Written Test

1.

a.	9	h.	10	o.	12
b.	3	i.	2	p.	17
c.	7	j.	4	q.	18
d.	1	k.	11	r.	19
e.	6	l.	13	s.	16
f.	5	m.	1	t.	15
g.	8	n.	14	u.	20

2. a. Clothing
   b. Hard hats, safety shoes
   c. Safety glasses
   d. Ties, dangling jewelry
   e. Long hair
   f. Rings, other jewelry
   g. Protective clothing
   h. Dust masks
   i. Hearing protection
   j. Gloves

3. **Awareness and safe conduct**—a, d, e, f
   Hygiene and safety from disease—None
   Fire safety—a
   Tool use, maintenance, and storage safety—a, d, e, g, h, i
   Hazardous materials safety—a, c
   Electrical safety—a, b, c, e

4. a. Equipment defects
   b. Any condition that can lead to an accident
   c. All accidents and injuries, no matter how minor

5.

a.	2	f.	3
b.	3	g.	1
c.	1	h.	4
d.	4	i.	3
e.	2	j.	3

6. b, c, d, h, i

7. a. Codes
   b. Metal cabinets
   c. Locked
   d. Away from
   e. Labels

8. a

Answers to Written Test

9. a. 3
   b. 1
   c. 4
   d. 2
   e. 2

10. a. By mouth
    b. Through the skin
    c. By breathing in gases, vapors, fumes, and other forms of a material

11. a. 6
    b. 5
    c. 1
    d. 3
    e. 2
    f. 4

12. a. 1
    b. 3
    c. 2
    d. 4

13. a. Fuel
    b. Heat
    c. Oxygen

14. a. 3
    b. 2
    c. 1
    d. 4

15. a. Pull pin.
    b. Aim nozzle toward fire.
    c. Squeeze handle.
    d. Sweep nozzle back and forth at base of flames.

16. a. 3
    b. 1
    c. 5
    d. 4
    e. 2

17. a. 2
    b. 5
    c. 6
    d. 3
    e. 7
    f. 1
    g. 4

Answers to Written Test

18.

a.	2	h.	2	o.	3
b.	4	i.	4	p.	3
c.	2	j.	3	q.	2
d.	3	k.	4	r.	2
e.	1	l.	1	s.	1
f.	4	m.	1	t.	1
g.	2	n.	4	u.	4

19. Answer should include any five of the following.

    a. Wipe up spills immediately.
    b. Post warning signs when floors are wet.
    c. Use handrails on stairs.
    d. Report any tripping hazard.
    e. Do not leave equipment, materials, or other obstacles in hallways, on stairs or landings, before doors and exits, or in any other area where people may trip over them.
    f. Do not stretch extension cords across traffic areas.
    g. Use a ladder instead of a chair or box to reach high objects or areas.

20.

a.	2	e.	4	i.	3	m.	1
b.	3	f.	2	j.	3	n.	4
c.	2	g.	3	k.	1	o.	2
d.	1	h.	1	l.	2	p.	1

21. a, c, d

22. b, c, d

23. a. Determine the type of emergency.
    b. Notify the appropriate medical or law-enforcement authority.
    c. Notify the management.
    d. Provide basic first aid, or seek assistance from other employees until proper authorities arrive.

24. a. Reason
    b. Reassure
    c. Accurate notes
    d. Notify
    e. Minor

Answers to Writen Test

25. **Bleeding**

    a. Apply pressure dressing or manual pressure to wound.
    b. Apply antiseptic solution and dress with sterile bandages.

    Burns

    a. Cool with a damp compress and then cover with a dry, sterile dressing; cover victim with a blanket to prevent loss of body heat.
    b. Cool with a damp compress—taking care not to break blisters—and then cover with a dry, sterile dressing to prevent infection.
    c. Hold under cold water; apply dry, sterile dressing.
    d. Flush skin thoroughly with clean water.
    e. Locate both entrance and exit burns, and treat as for a third-degree burn.

    Eye injury

    a. Minor: Have the victim close his or her eyes; put a piece of moist cotton over the closed lid; place a bandage over the cotton; get the victim to a doctor as soon as possible.
    b. More severe injury—Apply a sterile dressing, bandage *loosely*, and get medical help immediately.
    c. Chemical injury—Flush eyes immediately at an eye-flushing station, or use a bottled, portable flushing solution; then seek immediate medical assistance.

    Traumatic shock

    a. Recognize the signs and symptoms of traumatic shock.
    b. Lay victim down
    c. Elevate victim's legs slightly.
    d. Cover to prevent loss of body heat.

    Falls

    a. Lay victim flat; control bleeding.
    b. Check for injury and provide first aid as appropriate; do not move victim—or allow victim to move—if a neck or back injury is suspected.

Answers to Written Test

Choking

a. Recognize the signs and symptoms of choking.
b. Perform the Heimlich maneuver.

Heart attack

a. Recognize the signs and symptoms of heart attack.
b. Help victim to a less painful position.
c. Loosen victim's clothing around the neck and midriff.
d. Apply CPR if required and you are qualified.

Electrical accident

a. Do **not** provide any medical assistance until all electrical current has been shut off.
b. Administer CPR if necessary.
c. Treat for traumatic shock.
d. Treat for electrical burn.

Heat exhaustion

a. Recognize the signs and symptoms of heat exhaustion.
b. Immediately move victim to a cool place.
c. Lay victim flat.
d. Elevate victim's feet slightly.
e. Remove as much of victim's clothes as possible.
f. Sponge victim with cool water.

Heat stroke

a. Recognize the signs and symptoms of heat stroke.
b. Move victim to a cool location.
c. Cool victim as quickly as possible.
d. Rub ice on victim's extremities.

Bee stings

a. Scrape stinger sideways away from wound; wash wound with soap and water; apply ice to reduce swelling.
b. If possible, immediately transport victim to a hospital or doctor's office; if transportation is not immediately available, lay victim down or help victim to a position in which he or she can breathe more easily; elevate victim's legs if possible; while waiting for emergency help, remove stinger and perform first-aid actions for an ordinary sting.

Answers to Written Test

Seizure

a. Help victim lie on the ground or floor if possible.
b. Do not try to restrain victim.
c. Clear area of hard or dangerous objects to protect victim from self-injury.
d. Remove victim's eyeglasses, if applicable, and loosen clothing in the head and neck area.
e. Turn victim to the side to allow saliva to drain from the mouth.
f. Transport victim to a hospital or doctor's office after the seizure has passed.

General Safety and First Aid
Unit 2

Written Test

Name ____ Score ________________

1. Match terms realted to general safety with their correct definitions. Write the correct numbers in the blanks. Terms and definitions continue on the next page.

______a. Potential source of danger

______b. Failure to think before one acts; failure to pay attention

______c. Burn affecting only the outer skin layers; characterized by redness and pain

______d. Suddenly occurring, unintentional event that causes injury or property damage

______e. Freedom from danger, risk, or injury

______f. Form that lists and explains each of the hazardous materials that an employee works with so that the employee can safely use the material and respond to emergency situations

______g. Burn that destroys all skin layers and underlying tissue; characterized by white, leathery appearance and lack of pain

______h. The sudden stimulation of nerves and muscles caused by the discharge of electricity through the body when the body contacts an energized electrical circuit

______i. Procedure for restoring normal breathing after cardiac arrest

______j. Capable of bursting into flames at temperatures above 100°F

______k. Capable of being easily ignited and burning quickly at temperatures below 100°F

1. Accident
2. Cardiopulmonary resuscitation
3. Carelessness
4. Combustible
5. Material safety data sheet
6. Safety
7. First-degree burn
8. Third-degree burn
9. Hazard
10. Electrical shock
11. Flammable

Written Test

______l. Conditions or practices of cleanliness conducive to health

______m. Severe and sometimes fatal reaction to an antigen (as bee venom); characterized by respiratory symptoms, fainting, and itching

______n. Life-threatening blood-borne virus that depresses the cells of the immune system

______o. Any cancer-causing, corrosive, toxic, irritant, sensitizer, or material that has or has the potential for damaging effects on specific body organs

______p. Infectious disease marked by inflammation of the liver

______q. Burn penetrating beneath the superficial skin layers; characterized by swelling and blisters

______r. To apply pressure to the bottom of a straight or extension ladder to prevent it from slipping or sliding sideways while in use

______s. Immediate temporary care given the victim of an accident or sudden illness until the services of a physician can be obtained

______t. Federal legislation designed to ensure safe and healthful working conditions for employees

______u. Electrical connection to an object that conducts electrical current to the earth

12. Hazardous material
13. Hygiene
14. Acquired Immune Deficiency Syndrome (AIDS)
15. Occupational Safety and Health Act
16. First aid
17. Hepatitis
18. Second-degree burn
19. Heel
20. Grounded
21. Anaphylactic shock

Written Test

2. Complete guidelines for dressing safely on the job. Write the correct words in the blanks.

    a. Wear ________________ appropriate for the activity being performed.

    b. Wear ________________ and ________________ on all construction sites.

    c. Always wear ________________ when working.

    d. Remove ________________ and ________________ jewelry when working with or near machine tools or rotating equipment.

    e. Confine ________________ before operating rotating equipment.

    f. Remove ________________ and ________________ when working in the shop.

    g. Wear protective ________________ as appropriate.

    h. Wear ________________ in dusty areas.

    i. Wear ________________ when subjected to continuous loud noise.

    j. Wear ________________ when handling equipment and materials with sharp edges.

3. Select true general job and shop safety rules. Write an "X" in the blank before each true rule.

    Awareness and safet conduct

    ______a. Be alert for dangers and hazards.

    ______b. Conduct yourself in a safe manner; participate in horseplay only on break periods.

    ______c. Do not work overtime in the shop unless another student is present.

    ______d. Consider the safety of others.

    ______e. Do not distract workers operating a tool or machine.

    ______f. Work with adequate light.

Written Test

Fire safety

______a. Be familiar with the location of building exits and fire-fighting and first-aid equipment.

______b. Be aware of the voltage before plugging in a power tool.

Tool use, maintenance, and storage safety

______a. Use the right tool or equipment for the job, and use it properly.

______b. Keep all hand tools in an oil bath until needed.

______c. Retain all tool warranties and purchase orders.

______d. Operate a hazardous machine only after receiving instruction on how to operate the machine safely in all working conditions.

______e. Make sure that all guards and barriers are in place and adjusted properly before using a machine or tool.

______f. Use correct, properly fitting drill bit for nuts, bolts, and objects to be turned or held.

______g. Keep work areas clean and free of debris and other hazards.

______h. Store tools, materials, and supplies safely in cabinets, on shelves, or other suitable areas.

______i. Keep sufficient brooms, brushes, and other housekeeping equipment readily available.

______j. Clean chips from a machine with a rag or your bare hands, not with a brush.

______k. Wear hand protection when using grinders and buffers.

Hazardous materials safety

______a. Use a solvent only after determining its properties, the kind of work it has to do, and how to use it.

______b. Use and store potentially hazardous materials and products strictly according to warranty instructions and cautions.

______c. Clean up any spilled liquids immediately.

______d. Store oily rags or oily waste in self-closing or spring-lid plastic containers.

Written Test

Electrical safety

_____a. Check all equipment before energizing or activating.

_____b. Disconnect the power from energized tools, and tag or lockout machine tools, before performing any maintenance task such as oiling or cleaning.

_____c. Do not run over electrical cords with dollies or carts.

_____d. Tape down electrical cords that cross traffic lanes.

_____e. Turn off the power before leaving a power tool or machine.

4. List shop conditions that should be reported.

a. ____

b. ____

c. ____

5. Select words to complete facts about OSHA's role in workplace health and safety. Write the correct numbers in the blanks.

_____a. OSHA became federal law on April 28, ___.

1. 1961
2. 1971
3. 1984
4. 1974

_____b. OSHA operates under the U.S. Department of ___.

1. Health
2. Commerce
3. Labor
4. Human Services

_____c. OSHA sets ___ major requirements for employers.

1. two
2. three
3. four
4. five

Written Test

______d. OSHA requires each employer to furnish a place of employment that is free from recognized hazards that are causing or are likely to cause ___.

1. illness
2. allergic reactions
3. communicable diseases
4. death or serious injury

______e. OSHA requires that employers ___ the occupational safety and health standards contained within the OSHA regulations.

1. list
2. comply with
3. legalize
4. provide each employee with

______f. OSHA requires employees to comply with occupational safety and health standards and all rules, regulations, and orders pursuant to OSHA regulations that are applicable to the employee's own ___.

1. age
2. job description
3. actions and conduct
4. health and hygiene

______g. OSHA requires that employers ___ occupational injuries and illnesses of their employees.

1. keep records of
2. prevent all
3. provide insurance for all
4. list with the National Center for Disease Control all

______h. OSHA requires that employers keep ___ all hazardous substances used by employees.

1. in a locked cupboard
2. to a minimum
3. contact reports on
4. material safety data sheets on

Written Test

______i. OSHA often sets only ___ standards and requirements.

1. the strictest maximum
2. general
3. minimum
4. suggested

______j. OSHA provides for federal OSHA officers who visit facilities and ___.

1. arrest employers who are in noncompliance
2. fire employers/employees who are in noncompliance
3. levy penalties for noncompliance
4. train employees who are in noncompliance

6. Select true statements about hazardous cleaners and lubricants. Write an "X" in the blank before each true statement.

______a. Acetone is an acid that cleans solder connections.

______b. Kerosene may be used as a machine cutting fluid.

______c. Mineral spirits is a petroleum solvent that acts as a thinner for rubber, oil, and alkyd enamels.

______d. Bright dip is an acid mixture containing sulfuric, hydrochloric, and nitric acids.

______e. Lacquer thinner may be used as a coolant.

______f. Isophorone is used for oil and grease wash-up.

______g. Ethyl alcohol is not petroleum based.

______h. Hydrochloric acid is diluted acid that removes mill scale from steel.

______i. Cyclohexanone is a vinyl solvent and cement thinner.

7. Complete the following statements concerning the storage of hazardous materials. Circle the word(s) that best completes each statement.

a. Select an area that meets local, state, and national (*opinions, codes*).

b. Store materials in (*metal cabinets, plastic baskets*).

c. Keep storage area (*locked, open*).

d. Store in open area (*near, away from*) open flame or excessive heat.

e. Always read (*text, labels*) for instructions on proper storage use.

Written Test

8. Distinguish between two common hazardous materials found at the job site. Write "P" before the correct description of PCB.

______a. Used on ceilings, boilers, and electrical wiring as a heat retardant; highly suspected of causing cancer

______b. Fire resistant, helps improve the coolant and dielectric properties of oil; can be harmful if absorbed into the skin; suspected of being cancer-causing

9. Select words to complete the purposes of material safety data sheets (MSDS). Write the correct numbers in the blanks.

______a. To inform ___ of the material's physical properties or fast-acting health effects that make it dangerous to handle

1. OSHA
2. the management
3. the user
4. the health department

______b. To tell the user the level of ___ needed

1. protective gear
2. medical care
3. hygiene
4. management

______c. To tell the user the ___ necessary if exposed to the product or its hazards

1. preplanning
2. OSHA regulations
3. legal actions
4. first-aid treatment

______d. To tell the management and the user the ___ needed for safely handling spills, fires, and day-to-day operations

1. legal actions
2. preplanning
3. equipment and materials
4. personnel resources

______e. To tell the user how to ___ accidents

1. report
2. respond to
3. prevent
4. record

Written Test

10. Describe ways hazardous materials can enter the body.

a. Ingestion— ____

____

b. Absorption— ____

____

c. Inhalation— ____

____

11. Match the colors of the safety color code with their uses. Write the correct numbers in the blanks.

______a. Designates caution and for marking physical hazards, waste containers for explosive or combustible materials; caution against starting, using, or moving equipment under repair; identification of the starting point or power source of machinery

______b. Identifies fire protection equipment and apparatus, portable continers of flammable liquids, emergency stop bars, stop buttons, and emergency electrical stop switches on machinery

______c. Designates safety and the location of first aid equipment

______d. Designates dangerous parts of machines, safety starter buttons, parts of equipment that may produce electrical shock, and the exposed parts (edges only) of pulleys, gears, rollers, cutting devices, and power jaws

______e. Designates traffic flow; housekeeping zones

______f. Designates radiation hazards

1. Federal safety green
2. Federal safety white and black
3. Federal safety orange
4. Federal safety purple
5. Federal safety red
6. Federal safety yellow

Written Test

12. Match the illustrated safety tags with their color coding. Write the correct numbers in the blanks.

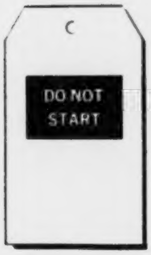
______a. White tag, white letters on red square

______b. White tag, white letters in red oval, on black square

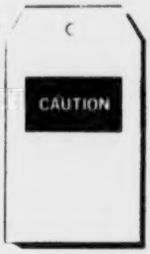
______c. Yellow tag, yellow letters on black background

______d. White tag, white letters on black background

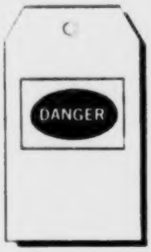
1.



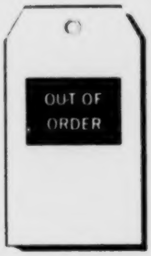
2.



3.



4.



13. List the components of the fire triangle.

a. ____________________

b. ____________________

c. ____________________

14. Match types of fires with their classifications. Write the correct numbers in the blanks.

______a. Fires that occur in electrical and electronic equipment

______b. Fires that occur in flammable liquids

______c. Fires that occur in ordinary combustible materials

______d. Fires that occur in combustible metals

1. Class A
2. Class B
3. Class C
4. Class D

Written Test

15. Complete fire extinguisher general operating instructions that follow the letters P-A-S-S.

a. P ______________________________

b. A ______________________________

c. S ______________________________

d. S ______________________________

16. Match types of fire extinguishers with their uses. Write the correct numbers in the blanks.

______a. Place foot on foot pump and direct stream at base of fire; use on Class A fires only.

______b. Direct discharge as close to fire as possible, first at the edge of flames, then gradually forward and upward; use for Class B or Class C fires

______c. Instead of spraying stream into the burning liquid, allow substance to fall lightly on the fire; use for Class A or Class B fires

______d. Direct at the base of the flames and follow up by directing at remaining material that is burning; use for Class B or Class C fires.

______e. Stand back 10 feet, hold upright and direct at the base of fire, sweeping from side to side; use for Class C fires.

1. Carbon dioxide
2. Halon
3. Pump tank
4. Dry chemical
5. Foam

Written Test

17. Match causes of back injuries with their contributing factors. Write the correct numbers in the blanks.

_____a. Injury usually results from overestimating your physical abilities and trying to lift more weight than you can handle, and sometimes it results from trying to be macho in front of fellow workers.

_____b. Injury usually results from moving an object that may be within your weight capacity, but is too long, high, or wide to lift safely.

_____c. Injury usually results from moving an object that may be within your weight capacity, but has a cylindrical or other odd shape that makes lifting difficult.

_____d. Injury usually results from stacking materials so high that vision is limited and obstructions in the pathways cannot be seen.

_____e. Injury usually results from twisting or turning to an awkward position when lifting.

_____f. Injury results in strain caused by not storing heavy objects at least 12 inches off the floor.

_____g. Injury usually results from carelessly using chairs or boxes instead of safely using a ladder, or by positioning elevating object too far from work.

1. Improper storage
2. Weight
3. Obstructions
4. Improper reaching
5. Size
6. Shape
7. Improper position

Written Test

18. Select words to complete guidelines for lifting and moving items safely. Write the correct numbers in the blanks.

Before lifting

______a. Inspect the item to be lifted for ___, and grease or other slippery surfaces.

1. wrapping, handholds
2. jagged edges, splinters
3. size, weight
4. obstacles, wrapping

______b. Wear ___ for protection, and make sure that they fit correctly.

1. steel-toed shoes
2. safety goggles
3. ankle supports
4. gloves

______c. Wear ___ support.

1. abdominal
2. lower-back
3. neck
4. shoulder

______d. Plan your ___ before you lift.

1. strategy
2. tactics
3. route
4. position

______e. Clear any ___ from your path.

1. obstacles
2. guests
3. employees
4. floor coverings

______f. Assess the ___ of the load

1. area
2. circumference
3. square footage
4. weight

Written Test

______g. ___ to lift heavy loads.

1. Use your back
2. Get help
3. Call a professional
4. Use a pry bar

______h. Use a ___ to move very heavy, large, or awkward loads that cannot (or should not) be lifted by two people.

1. ramp
2. dolly
3. laundry cart
4. bus cart

Lifting

______i. Place your ___ as close to the load as possible.

1. head
2. shoulders
3. hip
4. feet

______j. Bend your knees, keeping your ___ straight and your chin tucked in.

1. leg muscles
2. arms and shoulders
3. back and neck
4. feet

______k. Grasp the load ___ with your fingers and hands.

1. loosely
2. at the top
3. at the bottom
4. firmly

______l. Draw your ___ in close to your body.

1. arms
2. knees
3. feet
4. buttocks

______m. Stand slowly and lift smoothly, using your ___.

1. legs
2. shoulders
3. back
4. knees

Written Test

Carrying

______n. Hold the item ___.

1. at least 1 foot from waist
2. at knee level
3. at shoulder level
4. close to your body

______o. Do not allow the load to ___.

1. touch your chest
2. rest on your shoulder
3. block your vision
4. shift toward your body

______p. Do not ___ or twist you body to change direction.

1. set the load down
2. turn your head
3. change your grip
4. adjust your footing

______q. Learn the ___.

1. hip carry
2. shoulder carry
3. knee support carry
4. head carry

Setting the load down

______r. Bend your ___.

1. arms
2. knees
3. back
4. head

______s. Keep your ___ straight and aligned.

1. back and neck
2. knees and legs
3. arms and elbows
4. chin and head

Written Test

______t. Place the load carefully on the floor or shelf, taking care not to set it ___.

1. on your fingers or feet
2. on an even surface
3. toward the back of the receiving surface
4. squarely on the receiving surface

______u. Be sure the load is ___.

1. properly wrapped
2. closed
3. tied properly
4. secure

19. List five guidelines for preventing slips, trips, and falls.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

20. Select words to complete rules for using ladders safely. Write the correct numbers in the blanks.

______a. Make sure that the ladder has non-skid safety ___.

1. hooks
2. shoes
3. rungs
4. beams

______b. Inspect the ladder before use for worn safety shoes, broken or loose ___, or other defects.

1. paint
2. screws
3. rungs/steps
4. truss blocks

Written Test

______c. Inspect the ladder rungs/steps and siderails for ___ before you climb.

1. chipped or worn paint
2. oil or other slippery materials
3. levelness and construction
4. non-skid surfaces and dirt

______d. Be sure that ladders—particularly ___ ladders—are clear of electrical hazards.

1. metal
2. wood
3. fiberglass
4. composition

______e. Locate the ladder away from doors or other openings that are not ___.

1. open
2. closed
3. outswinging
4. blocked or guarded

______f. Place the ladder feet on a ___, non-skid surface.

1. perpendicular
2. level
3. smooth
4. vertical

______g. Place the ladder at a safe angle to the work: at least ___ from the wall for each ___ of height.

1. 6 inches; 1 foot
2. 2 feet; 10 feet
3. 1 foot; 4 feet
4. 8 inches; 3 feet

______h. Use ___ to secure sections of extension ladders.

1. rung locks
2. a screwdriver
3. properly knotted rope
4. vise-grip pliers

Written Test

______i. Place the top of extension and straight ladders at least ___ rungs above the work.

1. one
2. two
3. three
4. four

______j. Get a helper to ___ straight or extension ladders.

1. toe
2. foot
3. heel
4. boot

______k. ___ the ladder when climbing up and down.

1. Face
2. Keep your back to
3. Skip rungs of
4. Hug

______l. Never stand on the ___ rung/step.

1. lowest
2. top
3. center of the
4. edges of the

______m. Do not ___ while on the ladder; descend the ladder and reposition it instead.

1. overextend your reach
2. reach above your head
3. work to the right
4. work to the left

______n. Allow only ___ on the ladder at a time.

1. four persons
2. three persons
3. two persons
4. one person

Written Test

______o. Do not use ladders for ___.

1. cleaning windows
2. makeshift scaffolds
3. emergency exits
4. cleaning electrical fixtures

______p. Store ladders ___ when not in use.

1. securely
2. off the ground
3. in vertical position
4. on their sides

21. Select from a list safety guidelines for using scaffolds. Write an "X" in the blank before each safety practice.

______a. Never ride a scaffold when it is being moved.

______b. Scaffolding is easy to assemble and can be done alone.

______c. Secure scaffold wheel locks before climbing.

______d. Always use the proper planks when assembling.

______e. Never climb a scaffold unless at least three scaffold legs are on the ground.

22. Select from a list safety guidelines for using power lifts. Write an "X" in the blank before each safe practice.

______a. Operate lifts on uneven surfaces.

______b. Never lift over the weight-rated capacity of the lift.

______c. Always check for objects in the pathway.

______d. Never put arms or legs in lift.

______e. When moving lift, assume workers will get out of the way.

23. List in order the general steps for handling any emergency situation.

a. Step 1: ____

b. Step 2: ____

c. Step 3: ____

d. Step 4: ____

Written Test

24. Complete general guidelines for first aid emergencies. Write the word(s) that best completes each statement.

    a. Before administering first aid, always have a ______________ for what you do.

    b. ______________ the injured person that everything possible is being done.

    c. Make ______________ ______________ about the accident including name of victim, time, place, cause or nature of the accident, and any first aid that was administered.

    d. Do not ______________ the victim's family because this is the responsibility of the school, the job site supervisor, or the medical facility.

    e. Report all accidents and injuries to your instructor or job site supervisor, no matter how ______________ they may seem.

25. Describe basic first-aid procedures for various emergency situations.

    Bleeding

    a. Severe: ____

    ____

    b. Minor: ____

    ____

    Burns

    a. Third-degree: ___________________________________

    ____

    b. Second-degree: _________________________________

    ____

    c. First-degree: ___________________________________

    ____

d. Chemical: ____________________

____

e. Electrical: ____________________

____

Traumatic shock

a. ____________________

b. ____________________

c. ____________________

d. ____________________

Falls

a. Head injury: ____________________

____

b. Less severe falls: ____________________

____

Choking

a. ____________________

____

b. ____________________

____

Heart attack

a. ____________________

b. ____________________

c. ____________________

d. ____________________

Written Test

Electrical accident

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

Heat exhaustion

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

f. ______________________________

Heat stroke

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

Bee stings

a. Ordinary reaction: ______________________________

____

____

Written Test

b. Allergic reaction: ______________________________

____

____

____

____

Seizure

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

f. ______________________________

***Permission to duplicate this test is granted.**

General Safety and First Aid
Unit 2

Unit Evaluation Form

Student Name ______________________________ Unit Rating __________

Assignment Sheet 1—Interpret a Material Safety Data Sheet Rating _____

Comments: ____

____

Assignment Sheet 2—Draw a Layout of Your School Shop and Apply the Safety Color Code Rating _____

Comments: ____

____

Assignment Sheet 3—Interpret Portable Fire Extinguisher Symbols Rating _____

Comments: ____

____

Assignment Sheet 4—Identify and Correct Safety Violations Rating _____

Comments: ____

____

Job Sheet 1—Operate a Fire Extinguisher Rating _____

Comments: ____

____

Job Sheet 2—Lift a Heavy Object Properly Rating _____

Comments: ____

____

Job Sheet 3—Place and Climb a Ladder Safely Rating _____

Comments: ____

____

Unit Evaluation Form

Written Test Scores

Pretest ______ Posttest ______ Other ______

Other ____

____

Teacher Signature ______________________ Date __________

Student Signature ______________________ Date __________

***Permission to duplicate this form is granted.**

General Safety and First Aid
Unit 2

Teacher Supplement 1—OSHA Poster #2203

job safety and health protection

The Occupational Safety and Health Act of 1970 provides job safety and health protection for workers through the promotion of safe and healthful working conditions throughout the Nation. Requirements of the Act include the following:

Employers: **Each employer shall furnish to each of his employees employment and a place of employment free from recognized hazards that are causing or are likely to cause death or serious harm to his employees; and shall comply with occupational safety and health standards issued under the Act.**

Employees: **Each employee shall comply with all occupational safety and health standards, rules, regulations and order issued under the Act that apply to his own actions and conduct on the job.**

The Occupational Safety and Health Administration (OSHA) of the Department of Labor has the primary responsibility for administering the Act. OSHA issues occupational safety and health standards, and its Compliance Safety and Health Officers conduct jobsite inspections to ensure compliance with the Act.

Inspection: The Act requires that a representative of the employer and a representative authorized by the employees be given an opportunity to accompany the OSHA inspector for the purpose of aiding the inspection.

Where there is no authorized employee representative the OSHA Compliance Officer must consult with a reasonable number of employees concerning safety and health conditions in the workplace.

Complaint: Employees or their representatives have the right to file a complaint with the nearest OSHA office requesting an inspection if they believe unsafe or unhealthful conditions exist in their workplace. OSHA will withhold, on request, names of employees complaining.

The Act provides that employees may not be discharged or discriminated against in any way for filing safety and health complaints or otherwise exercising their rights under the Act.

An employee who believes he has been discriminated against may file a complaint with the nearest OSHA office within 30 days of the alleged discrimination.

Citation: If upon inspection OSHA believes an employer has violated the Act, a citation alleging such violations will be issued to the employer. Each citation will specify a time period within which the alleged violation must be corrected.

The OSHA citation must be prominently displayed at or near the place of alleged violation for three days, or until it is corrected, whichever is later, to warn employees of dangers that may exist there.

Proposed Penalty: The Act provides for mandatory penalties against employers of up to $1,000 for each serious violation and for optional penalties of up to $1,000 per day may be proposed for failure to correct violations within the proposed time period. Also, any employer who willfully or repeatedly violates the Act may be assessed penalties of up to $10,000 for each such violation.

Criminal penalties are also provided for in the Act. Any willful violation resulting in death of an employee, upon conviction, is punishable by a fine of not more than $10,000 or by imprisonment for not more than six months, or by both. Conviction of an employer after a first conviction doubles these maximum penalties.

Voluntary Activity: While providing penalties for violations, the Act also encourages efforts by labor and management, before an OSHA inspection, to reduce injuries and illnesses arising out of employment.

The Department of Labor encourages employers and employees to reduce workplace hazards voluntarily and to develop and improve safety and health programs in all workplaces and industries.

Such cooperative action would initially focus on the identification and elimination of hazards that could cause death, injury, or illness to employees and supervisors. There are many public and private organizations that can provide information and assistance in this effort, if requested.

More Information: **Additional information and copies of the Act, specific OSHA safety and health standards, and other applicable regulations may be obtained from your employer or from the nearest OSHA Regional Office in the following locations:**

Atlanta, Georgia
Boston, Massachusetts
Chicago, Illinois
Dallas, Texas
Denver, Colorado
Kansas City, Missouri
New York, New York
Philadelphia, Pennsylvania
San Francisco, California
Seattle, Washington

Telephone numbers for these offices, and additional Area Office locations, are listed in the telephone directory under the United States Department of Labor in the United States Government listing.

Washington, D.C.
1981
OSHA 2203

Raymond J Donovan

Raymond J. Donovan
Secretary of Labor

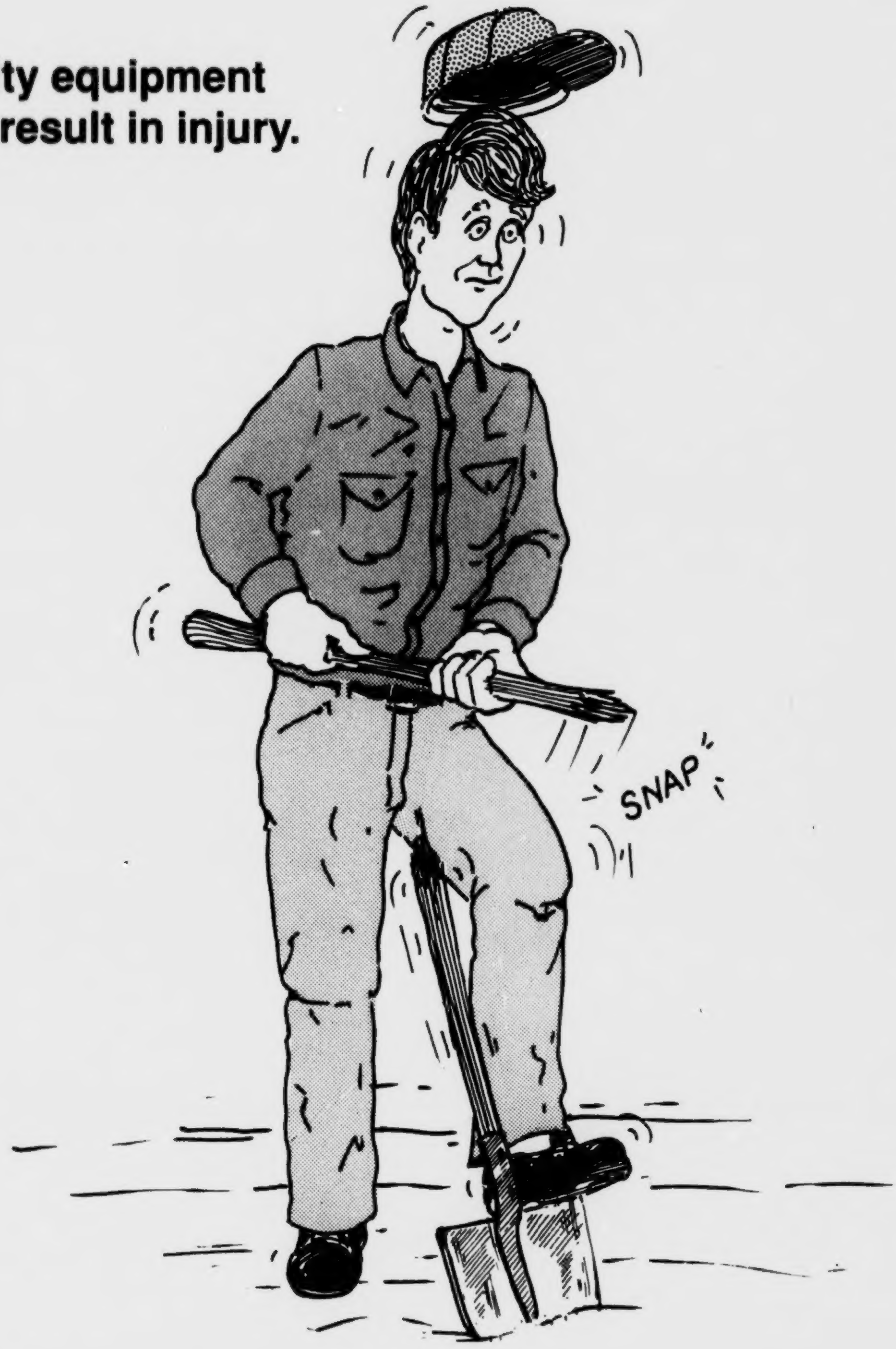
U.S. Department of Labor

Occupational Safety and Health Administration
GPO 888-385

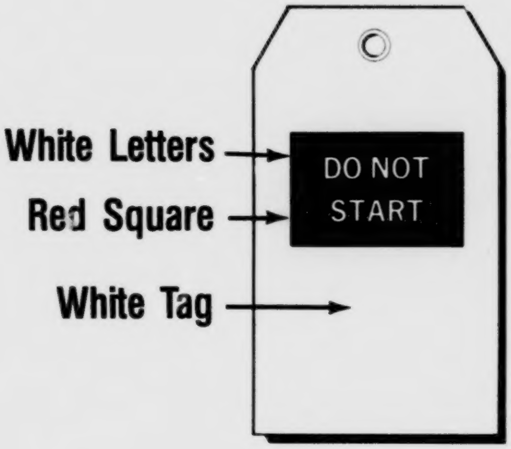
127

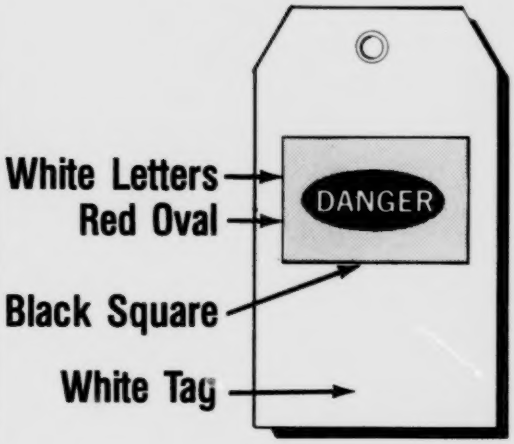
Maintain Tools

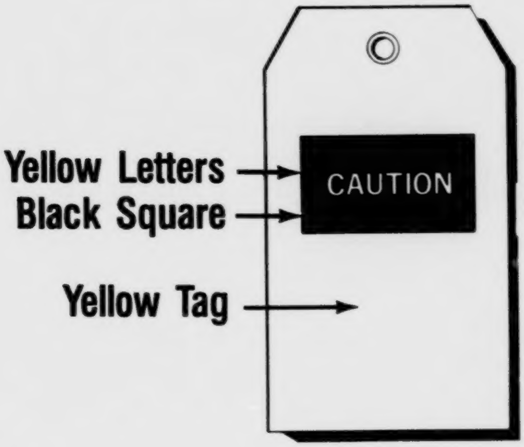
Faulty equipment can result in injury.

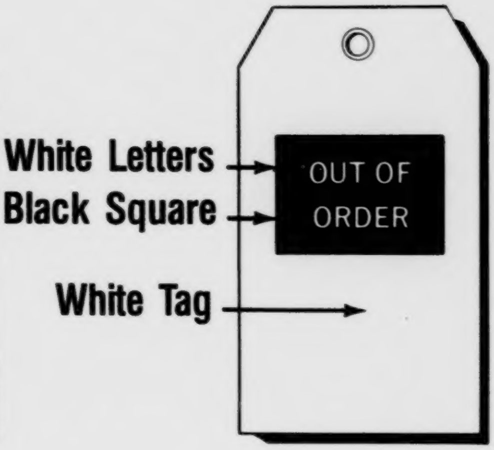


Safety Tag Color Codes


White Letters
Red Square
White Tag
DO NOT START

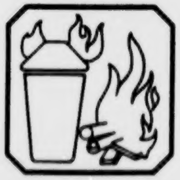

White Letters
Red Oval
Black Square
White Tag
DANGER


Yellow Letters
Black Square
Yellow Tag
CAUTION


White Letters
Black Square
White Tag
OUT OF ORDER

Classes of Fuel or Fires

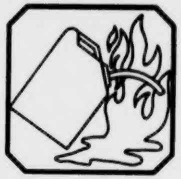
A



Class A
(Green)

- Ordinary combustibles

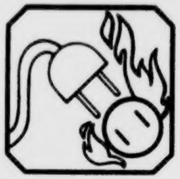
B



Class B
(Red)

- Flammable liquids and gases

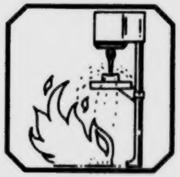
C



Class C
(Blue)

- Live electrical equipment

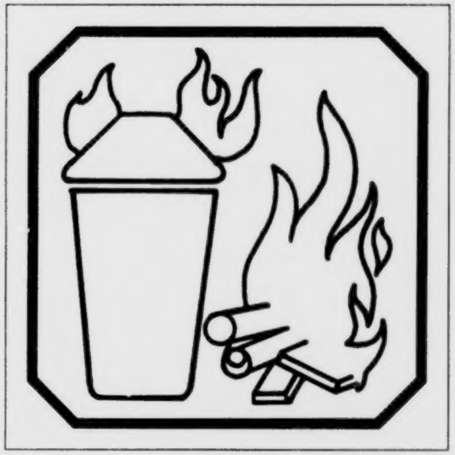
D



Class D
(Yellow)

- Combustible metals

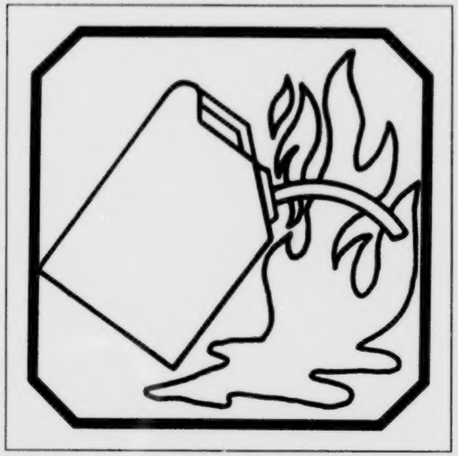
Extinguisher Markings



Ordinary

A

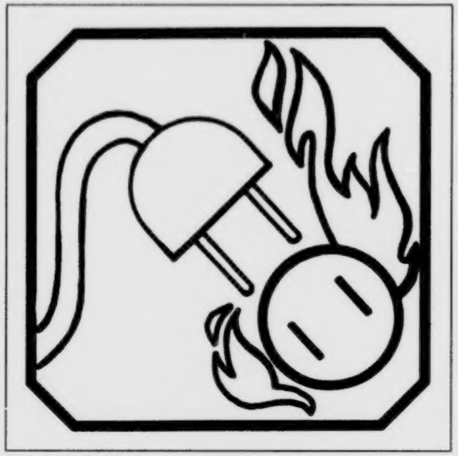
Combustibles
(Green)



Flammable

B

Liquids
(Red)

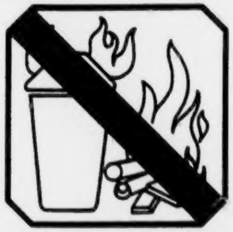
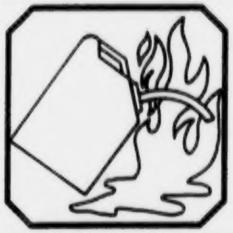
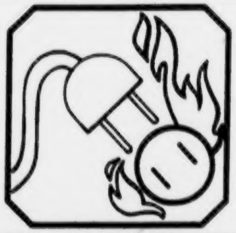
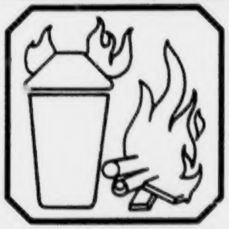
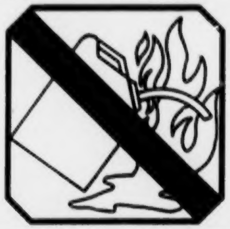
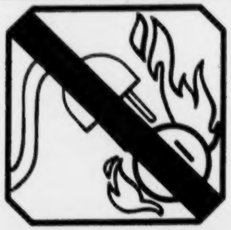
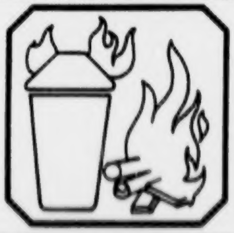
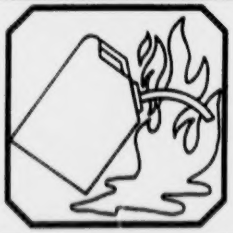
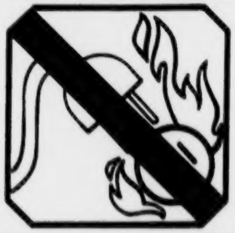


Electrical

C

Equipment
(Blue)

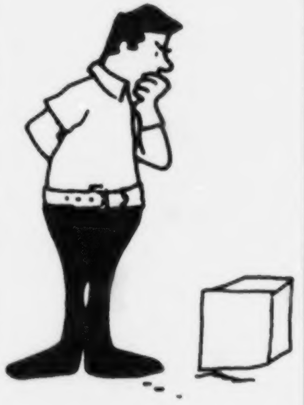
Extinguisher Picture Symbols

			Picture symbols for extinguishers suitable for Class B and C fires, but **not** for Class A fires.
			Picture symbols for extinguishers suitable for Class A fires, but **not** for Class B and C fires.
			Picture symbols for extinguishers suitable for Class A and B fires, but **not** for Class C fires.

How to Lift Safely

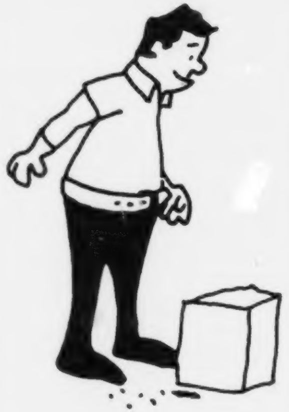
1

Approach the load and size it up as to weight, size, and shape. Consider your physical ability to handle the load.



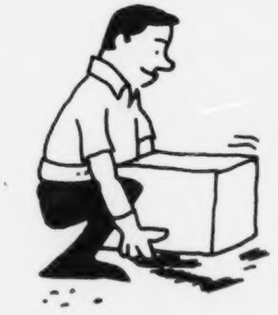
2

Place feet close to the object to be lifted and 8 to 12 inches apart for good balance.



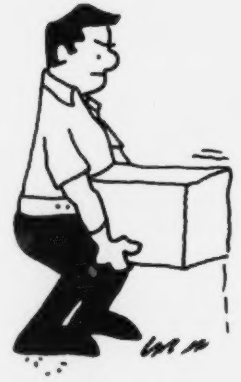
3

Bend the knees to the degree that is comfortable and get a good handhold. Then using both leg and back muscles . . .



4

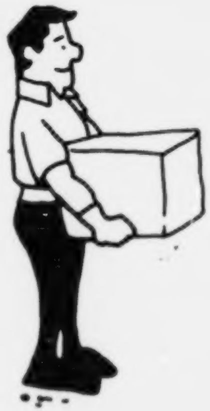
Lift the load straight up smoothly and evenly. Push with your legs, and keep the load close to your body.



How to Lift Safely
(Continued)

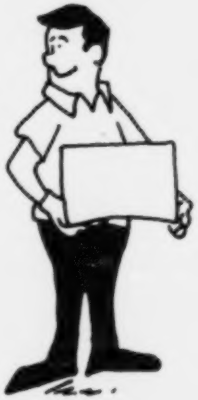
5

Lift the object into carrying position, making no turning or twisting movements until the lift is completed.



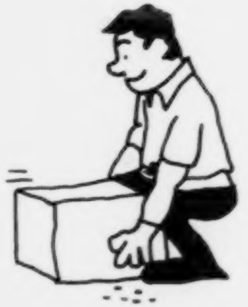
6

Turn your body with changes of foot position after looking over your path of travel, making sure it is clear.

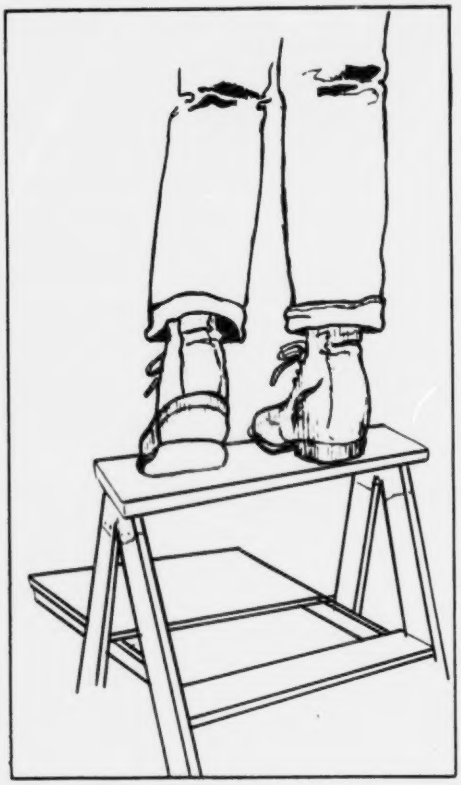


7

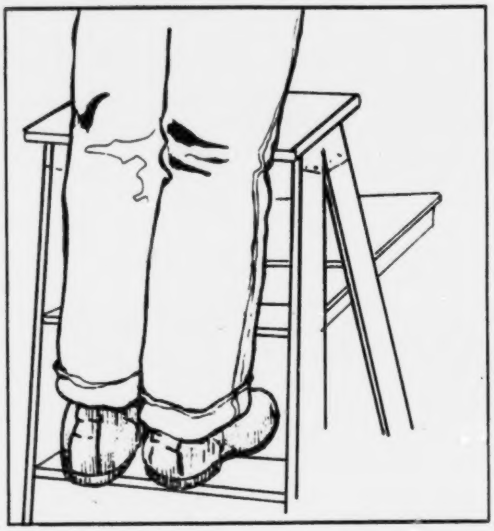
Setting the load down is just as important as picking it up. Using leg and back muscles, comfortably lower load by bending your knees. When load is securely positioned, release your grip.



Safety Practices for Step Ladders

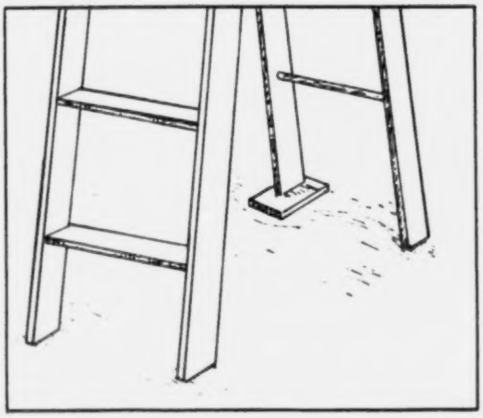


Incorrect

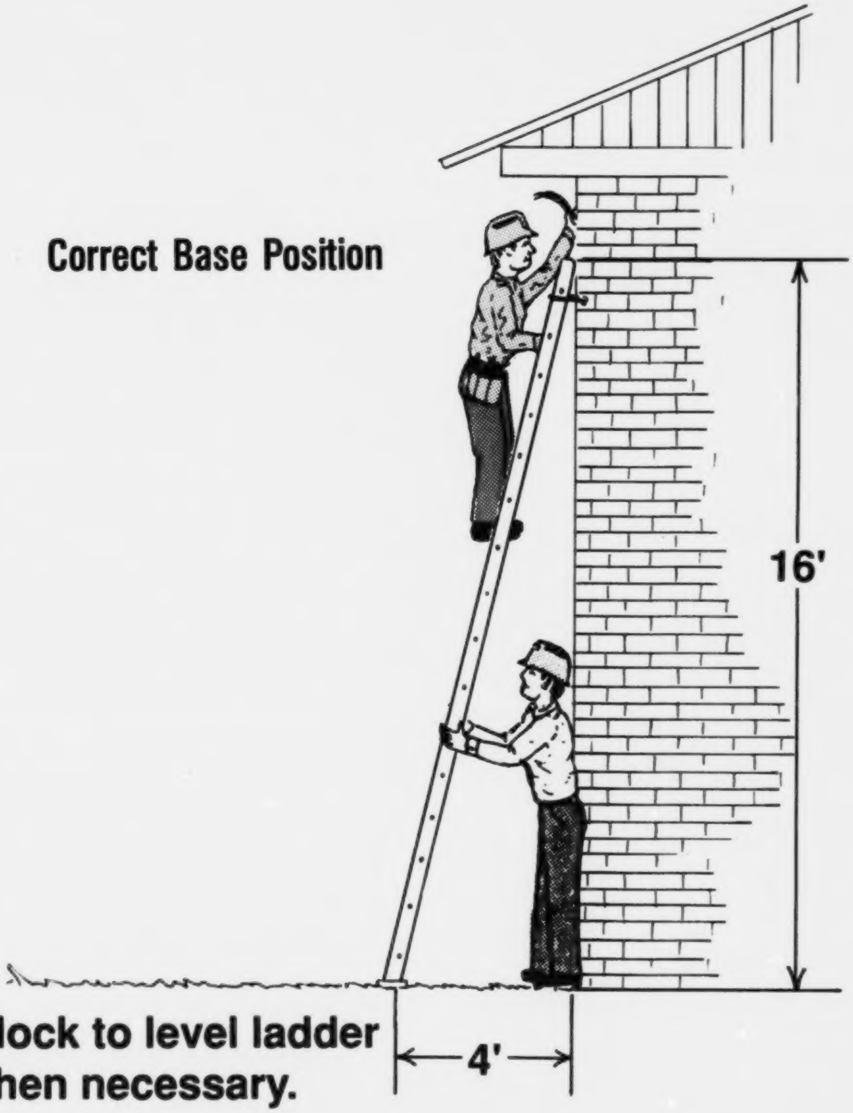


Correct

Use block to level ladder when necessary.



Safe Ladder Angle

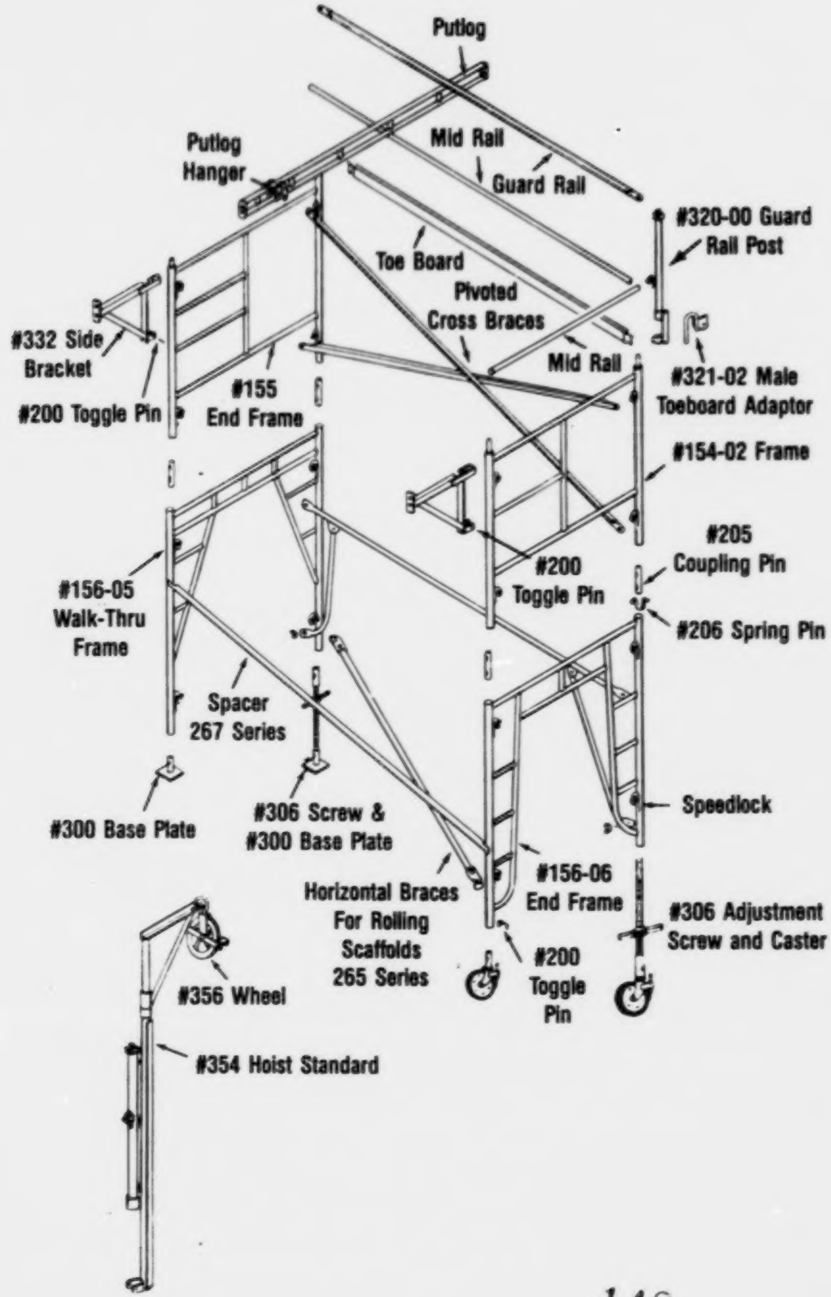


Correct Base Position

Use block to level ladder when necessary.

Correct base position is 1/4 the vertical height.

Scaffold Construction


Putlog
Putlog Hanger
Mid Rail
Guard Rail
#320-00 Guard Rail Post
Toe Board
Pivoted Cross Braces
#332 Side Bracket
Mid Rail
#321-02 Male Toeboard Adaptor
#200 Toggle Pin
#155 End Frame
#154-02 Frame
#205 Coupling Pin
#200 Toggle Pin
#156-05 Walk-Thru Frame
#206 Spring Pin
Spacer 267 Series
Speedlock
#300 Base Plate
#306 Screw & #300 Base Plate
#156-06 End Frame
Horizontal Braces For Rolling Scaffolds 265 Series
#306 Adjustment Screw and Caster
#356 Wheel
#200 Toggle Pin
#354 Hoist Standard

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General Safety and First Aid
Unit 2

Information Sheet

1. **Terms and definitions associated with general safety and first aid**

   a. **Accident** — Suddenly occurring, unintentional event that causes injury or property damage

   b. **Acquired Immune Deficiency Syndrome (AIDS)** — Life-threatening blood-borne virus that depresses the cells of the immune system

      Note: It is important to protect yourself against AIDS infection when administering first aid to a victim. See Information Sheet Objective 27.

   c. **Anaphylactic shock** — Severe and sometimes fatal reaction to an antigen (as bee venom); characterized by respiratory symptoms, fainting, and itching

   d. **Cardiopulmonary resuscitation** (CPR) — Procedure for restoring normal breathing after cardiac arrest

   e. **Carelessness** — Failure to think before one acts; failure to pay attention

   f. **Combustible** — Capable of bursting into flames at temperatures above 100°F

   g. **Electrical shock** — The sudden stimulation of nerves and muscles caused by the discharge of electricity through the body when the body contacts an energized electrical circuit

      Note: Electrical shock can cause serious burns, muscle damage, and death. Human body resistance varies from about 500,000 ohms when dry to about 300 ohms when wet. Because of this, voltages as low as 30 volts can cause enough current to be fatal. Any circuit with a potential of at least 30 volts must be considered dangerous.

   h. **First aid** — Immediate temporary care given the victim of an accident or sudden illness until the services of a physician can be obtained

   i. **First-degree burn** — Burn affecting only the outer skin layers; characterized by redness and pain

   j. **Flammable** — Capable of being easily ignited and burning quickly at temperatures below 100°F

      Note: *Inflammable* means "flammable."

Information Sheet

k. **Grounded** — Electrical connection to an object that conducts electrical current to the earth

l. **Hazard** — Potential source of danger

m. **Hazardous material** — Any cancer-causing, corrosive, toxic, irritant, sensitizer, or material that has, or has the potential for, damaging effects on specific body organs

Examples: Bleaches, petroleum products, paints, chlorine and other pool chemicals, cleaning and sanitizing agents, varnishes, paint removers, carbon monoxide from vehicle exhausts

n. **Heel** — To apply pressure to the bottom of a straight or extension ladder to prevent it from slipping or sliding sideways while in use

o. **Hepatitis** — Infectious disease marked by inflammation of the liver

Note: It is important to protect yourself against hepatitis infection when administering first aid to a victim. See Information Sheet Objective 27.

p. **Hygiene** — Conditions or practices of cleanliness conducive to health

q. **Material safety data sheet** (MSDS) — Form that lists and explains each of the hazardous materials that an employee works with so that the employee can safely use the material and respond to emergency situations

Note: The federal Hazardous Communications Act (HAZCOM) states that all employees must have access to MSDSs and be taught to read and understand them.

r. **Occupational Safety and Health Act** (OSHA) — Federal legislation designed to ensure safe and healthful working conditions for employees

s. **Safety** — Freedom from danger, risk, or injury

t. **Second-degree burn** — Burn penetrating beneath the superficial skin layers; characterized by swelling and blisters

u. **Third-degree burn** — Burn that destroys all skin layers and underlying tissue; characterized by white, leathery appearance and lack of pain

Note: Third-degree burns are not painful because nerve tissue has been destroyed.

Information Sheet

2. Dressing safely on the job

a. Wear clothing appropriate for the activity being performed.

b. Wear hard hats and safety shoes on all construction sites.

c. Always wear safety glasses when working.

d. Remove ties and dangling jewelry when working with or near machine tools or rotating equipment.

e. Confine long hair before operating rotating equipment.

f. Remove rings and other jewelry when working in the shop.

g. Wear protective clothing as appropriate.

Example: Suitable helmets and goggles when welding; eye protection when using electric tools such as saws or drills; facemask when working with invasive fumes; seatbelt at all times when in a moving vehicle

h. Wear dust masks in dusty areas.

i. Wear hearing protection when subjected to continuous loud noise.

j. Wear gloves when handling equipment and materials with sharp edges.

3. General job and shop safety

a. **Awareness and safe conduct**

- Be alert for dangers and hazards.
- Conduct yourself in a safe manner; do not participate in horseplay.
- Do not work overtime in the shop unless the instructor is present.
- Consider the safety of others.
- Do not distract workers operating a tool or machine.
- Work with adequate light.

Information Sheet

b. **Hygiene and safety from disease**

- Do not come to work or school sick, and do not continue working if you become sick.
- Use soap and water frequently as a method of preventing and transferring disease.

c. **Fire safety**

- Be familiar with the location of building exits, and fire-fighting and first-aid equipment.
- Be aware of the surroundings before plugging in a power tool.

  Example: Are there any explosives or combustible materials in the area?

d. **Tool use, maintenance, and storage safety**

- Use the right tool or equipment for the job, and use it properly.

  Examples: A stepladder instead of furniture; a screwdriver or scraping tool, not the tip of a kitchen knife

- Keep all tools, sharp, clean, and in safe working order.
- Retain all tool guards and safety devices.
- Operate a hazardous machine only after receiving instruction on how to operate the machine safely in all working conditions.
- Make sure that all guards and barriers are in place and adjusted properly before using a machine or tool.
- Use correct, properly fitting wrenches for nuts, bolts, and objects to be turned or held.
- Keep work areas clean and free of debris and other hazards.
- Store tools, materials, and supplies safely in cabinets, on shelves, or other suitable areas.
- Keep sufficient brooms, brushes, and other housekeeping equipment readily available.
- Clean chips from a machine with a brush, not with a rag or your bare hands.
- Wear eye protection when using grinders and buffers.

Information Sheet

e. **Hazardous materials safety**

- Use a solvent only after determining its properties, the kind of work it has to do, and how to use it.
- Use and store potentially hazardous materials and products strictly according to label instructions and cautions.
- Clean up any spilled liquids immediately.
- Store oily rags or oily waste in self-closing or spring-lid metal containers.

f. **Elecrtrical safety**

- Check all equipment before energizing or activating.
- Disconnect the power from energized tools, and tag or lockout machine tools, before performing any maintenance task such as oiling or cleaning.
- Do not run over electrical cords with dollies or carts.
- Do not string electrical cords across traffic lanes.
- Turn off the power before leaving an energized tool or machine.

4. **Shop conditions that should be reported**

a. Equipment defects

b. Any condition that can lead to an accident

c. All accidents and injuries, no matter how minor

5. **Facts about OSHA's role in workplace health and safety**

a. Became federal law on April 28, 1971

b. Operates under the U.S. Department of Labor

c. Sets two major requirements for employers:

- To furnish each employee a place of employment that is free from recognized hazards that are causing or likely to cause death or serious injury to employees
- To comply with the occupational safety and health standards contained within the OSHA regulations

Information Sheet

d. Sets one major requirement for employees:

  - To comply with occupational safety and health standards and all rules, regulations, and orders pursuant to OSHA regulations that are applicable to the employee's own actions and conduct

e. Requires employers to keep records of occupational injuries and illnesses of their employees

Note: Employers must record all occupational fatalities, lost-workday illnesses and injuries, and nonfatal illnesses and injuries without lost workdays but which require medical treatment. Medical treatment does not include first-aid treatment.

f. Requires that employers keep material safety data sheets (MSDSs) on all hazardous substances used by employees

g. Often sets only minimum standards and requirements

h. Provides for federal OSHA officers who inspect facilities and levy penalties for noncompliance

6. Hazardous cleaners and lubricants

Note: Many cleaners and lubricants contain petroleum, acids, and/or alkaline bases that may be hazardous to your health. Read and follow label instructions for proper use and storage.

Cleaner	Type	Application
Alcohol, ethyl	Petroleum solvent	Cleaning solder connections Thinning shellac and rosin
Acetone	Petroleum solvent	Removing oily films, paints, and lacquer Cementing lucite
Bright dip	Acid mixture containing sulfuric, hydrochloric, and nitric acids	Cleaning metal surfaces after etching or soldering
Butyl cellulose	Petroleum solvent	Thinning and washing epoxy resin inks
Cyclohexanone	Petroleum solvent	Thinning vinyl solvents and cements
Hydrochloric acid	Diluted acid	Removing mill scale from steel (bright dip ingredient)

Information Sheet

Cleaner	Type	Application
Isophorone	Petroleum solvent	Washing up vinyl inks
Isopropyl alcohol	Petroleum solvent	Removing oil, grease, and flux from conductors and terminals, both before and after soldering
Kerosene	Petroleum solvent	Cutting machine fluid
Ketone, methyl ethyl	Petroleum solvent	Thinning lacquer and removing paint
Lacquer thinner	Petroleum solvent	Thinning and washing up lacquer and lacquer ink
Mineral spirits	Petroleum solvent	Washing up and thinning rubber, oil, ethyl cellulose inks, and alkyd enamels
Perchlorethylene	Chlorinated solvent	General-purpose cleaning and vapor degreasing
Phosphoric acid	Diluted acid	Removing milk scale from steel
Sodium hydroxide	Alkaline solvent	Cleaning and etching aluminum
Toluene	Petroleum solvent	Washing up and thinning rubber, oil, ethyl cellulose inks, and alkyd enamels
Trichloroethane	Chlorinated solvent	Washing up layout dye and screen inks Ultrasonic cleaning
Trichlorethylene	Chlorinated solvent	General-purpose cleaning and vapor degreasing
Turpentine	Petroleum solvent	Cutting machine fluid
Xylene	Petroleum solvent	Thinning acrylic printing inks Washing up synthetic enamels and photo resist ink

Lubricant	Application
WD40	General purpose lubricant
3-in-1 oil	General purpose lubricant

Information Sheet

7. **Storage of hazardous materials**

    a. Select an area that meets local, state, and national codes.

    b. Store materials in metal cabinets.

    c. Keep cabinet or storage area locked.

    d. Store in an area away from open flame or excessive heat.

    e. Always read labels and follow instructions for proper stroage.

8. **Two common hazardous materials found at electrical job sites**

    a. **PCB (Polychlorinated Biphenyl)** — Fire resistant; helps improve the coolant and dielectric properties of oil; can be harmful if absorbed into the skin; suspected of being cancer-causing

    Note: PCBs are considered serious environmental contaminants.

    b. **Asbestos** — Used on ceilings, boilers, and electrical wiring as a heat retardant; highly suspected of causing cancer

    Note: OSHA requires employers to test for asbestos fibers in the air. The results determine the control measures taken to protect employees.

9. **Purposes of material safety data sheets (MSDS)**

    a. To inform the user of the material's physical properties or fast-acting health effects that make it dangerous to handle

    b. To tell the user the level of protective gear needed

    c. To tell the user the first aid treatment necessary if exposed to the product or its hazards

    d. To tell the management and the user the preplanning needed for safely handling spills, fires, and day-to-day operations

    e. To tell the user how to respond to accidents

Information Sheet

10. **Ways hazardous materials can enter the body**

    a. **Ingestion**—By mouth

    Example: Swallowing paint thinner

    b. **Absorption**—Through the skin

    Example: Getting some PCB on your hands or skin

    c. **Inhalation**—By breathing in gases, vapors, fumes, and other forms of a material

    Example: Inhaling asbestos particles

11. **Colors of the safety color code and their uses**

    Note: The following colors identify safe and unsafe conditions in the shop. Learn the color code because it could help you prevent accidents to yourself and fellow workers.

    a. **Federal safety red** — Basic color for identifying

    - Fire protection equipment and apparatus
    - Portable containers of flammable liquids
    - Emergency stop bars, stop buttons, and emergency electrical stop switches on machinery

    b. **Federal safety yellow** — Basic color for designating

    - Caution and for marking physical hazards
    - Waste containers for explosive or combustible materials
    - Caution against starting, using, or moving equipment under repair
    - Identification of the starting point or power source of machinery

    c. **Federal safety orange** — Basic color for designating

    - Dangerous parts of machines
    - Safety starter buttons and parts of equipment that may produce electrical shock
    - The exposed parts (edges only) of pulleys, gears, rollers, cutting devices, and power jaws

Information Sheet

d. **Federal safety purple** — Basic color for designating radiation hazards

e. **Federal safety green** — Basic color for designating

- Safety
- Location of first aid equipment

  Note: This applies to equipment other than fire fighting equipment.

f. **Federal safety black and white** — Basic colors for designating

- Traffic flow
- Housekeeping zones

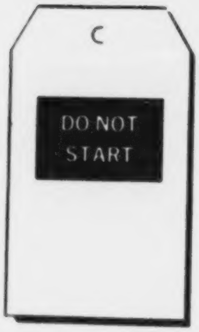
  Note: Black and white colors are used individually or in combination.

12. **Color coding of safety tags or signs** (Figures 1-4)

a. Do not start tag (Figure 1)

- White tag
- White letters on red square

Figure 1

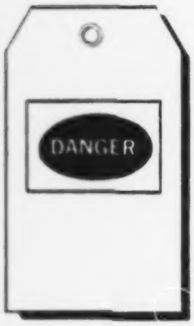


Information Sheet

b. Danger tag (Figure 2)

- White tag
- White letters in red oval, on black square

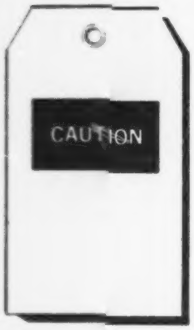
Figure 2



c. Caution tag (Figure 3)

- Yellow tag
- Yellow letters on black background

Figure 3

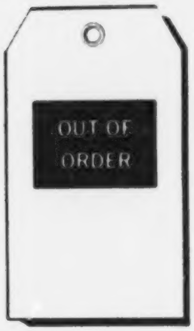


Information Sheet

d. Out of order tag (Figure 4)

- White tag
- White letters on black background

Figure 4


OUT OF
ORDER

13. **Components of the fire triangle** (Figure 5)

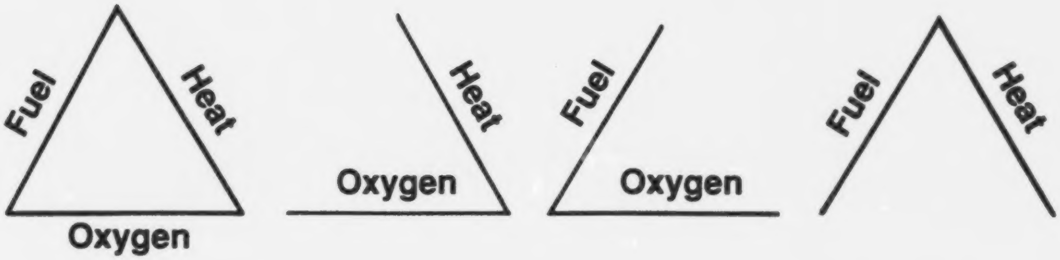
a. Fuel — Any combustible material

b. Heat — Enough to raise the fuel to its ignition temperature

c. Oxygen — Necessary to sustain combustion

Note: To produce fire, the three elements of the fire triangle must be present at the same time. If any one of the three is missing, a fire cannot be started. With the removal of any one element, the fire will be extinguished.

Figure 5


Fuel
Heat
Oxygen
Heat
Oxygen
Fuel
Oxygen
Fuel
Heat

Information Sheet

14. **Types of fires and their classifications**

    a. **Class A** — Fires that occur in ordinary combustible materials

    Examples: Wood, rags, paper, or trash

    b. **Class B** — Fires that occur in flammable liquids

    Examples: Gasoline, oil, grease, paints, or thinners

    c. **Class C** — Fires that occur in electrical and electronic equipment

    Examples: Motors, switchboards, circuit wiring, radios, or television sets

    d. **Class D** — Fires that occur in combustible metals

    Examples: Powdered aluminum or magnesium

15. **Fire extinguisher general operating instructions that follow the letters P-A-S-S**

    a. **P**-ull the pin at the top of the extinguisher that prevents the handle from being pressed.

    b. **A**-im the nozzle toward the fire.

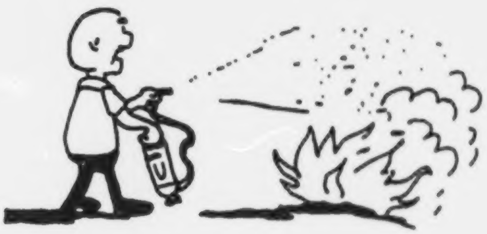
    c. **S**-queeze the handle to discharge the extinguishing agent.

    d. **S**-weep the nozzle back and forth at the base of the flames to disperse the extinguishing agent.

16. **General types of fire extinguishers and their uses** (Figures 6-10)

    a. **Foam** — Instead of spraying stream into the burning liquid, allow foam to fall lightly on the fire; use for Class A or Class B fires.

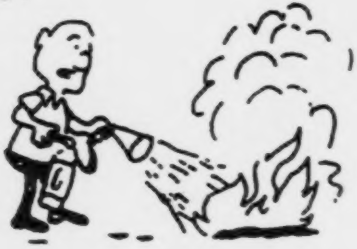
    Figure 6



Information Sheet

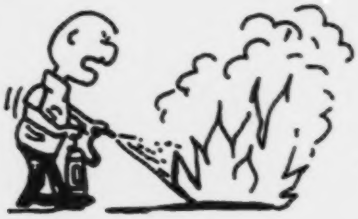
b. **Carbon dioxide** — Direct discharge as close to fire as possible, first at the base of flames, then gradually forward and upward; use for Class B or Class C fires.

Figure 7



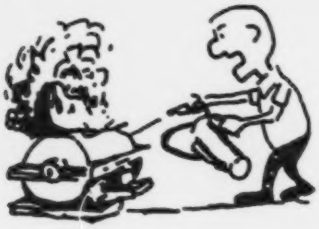
c. **Pump tank** — Place foot on foot pump and direct stream at base of flames; use on Class A fires only.

Figure 8



d. **Dry chemical** — Direct at the base of the flames; follow up by directing the dry chemicals at remaining materials that are burning; use for Class B or Class C fires.

Figure 9

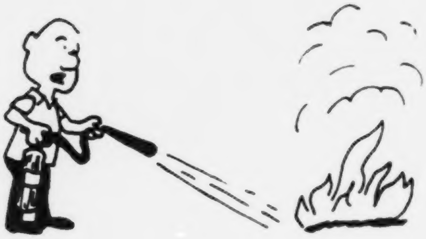


e. **Halon** — Direct at base of flames, sweeping from side to side; use for Class C fires.

Note: Halon is a clean, liquified gas that does not leave a residue.

Caution: A high concentration halon gas may be hazardous to your health because is displaces oxygen in air.

Figure 10

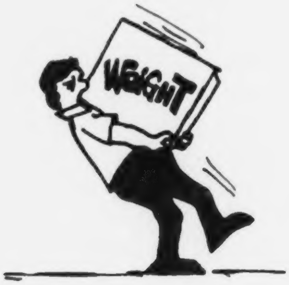


17. **Contributing factors and causes of back injuries** (Figures 11-17)

a. **Weight** — Injury results from overestimating your physical abilities and trying to lift more weight than you can handle.

Note: Sometimes back injuries caused by trying to lift too heavy an object result from trying to be macho in front of fellow workers.

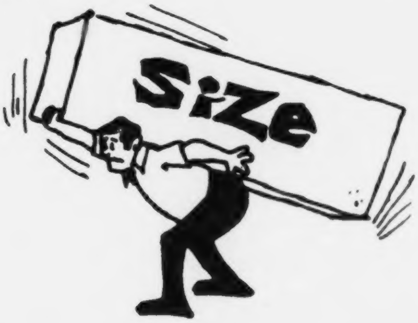
Figure 11



Information Sheet

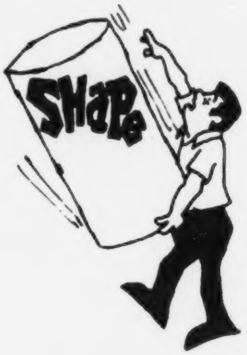
b. **Size** — Injury usually results from moving an object that may be within your weight capacity, but is too long, high, or wide to lift safely.

Figure 12



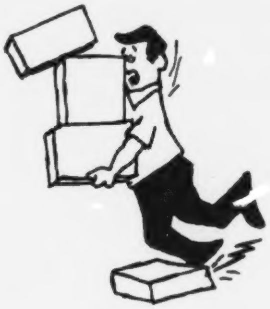
c. **Shape** — Injury usually results from moving an object that may be within your weight capacity, but has a cylindrical shape or other odd shape that makes safe lifting difficult.

Figure 13



d. **Obstructions** — Injury usually results from stacking materials so high that vision is limited and obstructions in the pathway cannot be seen.

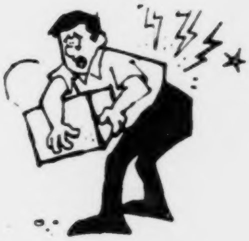
Figure 14



Information Sheet

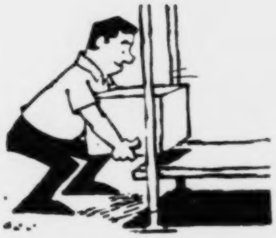
e. **Improper position** — Injury usually results from twisting or turning to an awkward position when lifting.

Figure 15



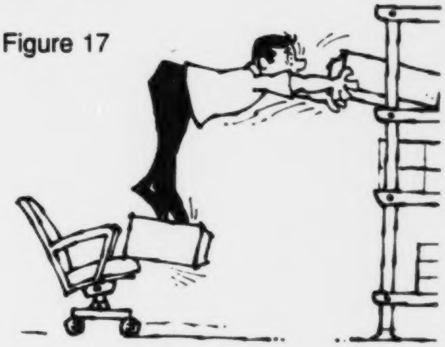
f. **Improper storage** — Injury usually results in strain caused by not storing heavy objects at least 12 inches off the floor.

Figure 16



g. **Improper reaching** — Injury usually results from carelessly using chairs or boxes instead of safely using a ladder, or by positioning elevating object too far from work.

Figure 17



Information Sheet

18. Guidelines for lifting and moving items safely

a. Before lifting

- Inspect the item to be lifted for jagged edges, splinters, and grease or other slippery surfaces.
- Wear gloves for protection, and make sure that they fit properly.
- Wear lower-back support.

  Example: Leather lower-back support belt
- Plan your route before you lift.
- Clear any obstacles from your path.
- Assess the weight of the load.
- Get help to lift heavy loads.

  Note: Teamwork works best when both persons are about the same size. The load should be distributed evenly between both workers.
- Use a dolly to move very heavy, large, or awkward loads that cannot (or should not) be lifted by two people.

  Examples: Piano, refrigerator, sofa bed

b. Lifting

- Place your feet as close to the load as possible, one foot alongside the load and the other behind it.
- Bend your knees, keeping your back and neck straight and your chin tucked in.
- Grasp the load firmly with your fingers and hands.
- Draw your arms in close to your body.
- Stand slowly and lift smoothly, *using your legs.*

Information Sheet

c. **Carrying**

- Hold the item close to your body.
- Do not allow the load to block your vision.
- Do not change your grip or twist your body to change direction.

  Note: To avoid back injury, turn with your feet and move your whole body.
- Learn the shoulder carry.

d. **Setting the load down**

- Bend your knees.
- Keep your back and neck straight and aligned.
- Place the load carefully on the floor or shelf, taking care not to set it on your fingers or feet.
- Be sure the load is secure.

19. **Guidelines for preventing slips, trips, and falls**

a. Wipe up spills immediately.

b. Post warning signs when floors are wet.

c. Use handrails on stairs.

d. Report any tripping hazard.

Examples: Loose boards, loose tiles, broken steps, torn or curled carpets

e. Do not leave equipment, materials, or other obstacles in hallways, on stairs or landings, before doors and exits, or in any other area where people may trip over them.

f. Do not stretch extension cords across traffic areas.

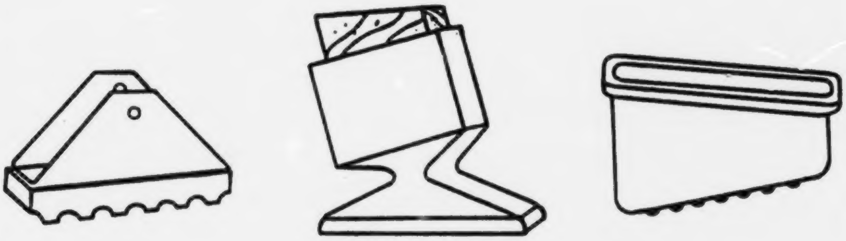
g. Use a ladder instead of a chair or box to reach high objects or areas.

Information Sheet

20. Rules for using ladders safely

a. Make sure that the ladder has non-skid safety shoes. (Figure 18)

Figure 18



Shoe for
metal stepladder

Rubber shoe for
wood extension ladder

Rubber shoe for
either wood or
metal stepladder

b. Inspect the ladder before use for worn safety shoes, broken or loose rungs/steps, or other defects.

c. Inspect the ladder rungs/steps and siderails for oil or other slippery materials before you climb.

d. Never use metal ladders for electrical work.

e. Locate the ladder away from doors or other openings that are not blocked or guarded.

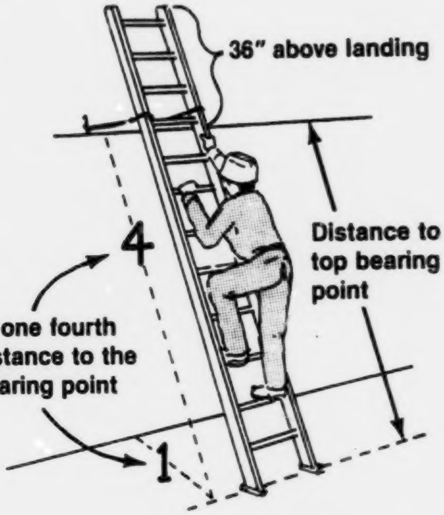
f. Place ladder feet on a level, non-skid surface.

Information Sheet

g. Place ladder at a safe angle to the work: at least 1 foot from the wall for every 4 feet of height. (Figure 19)

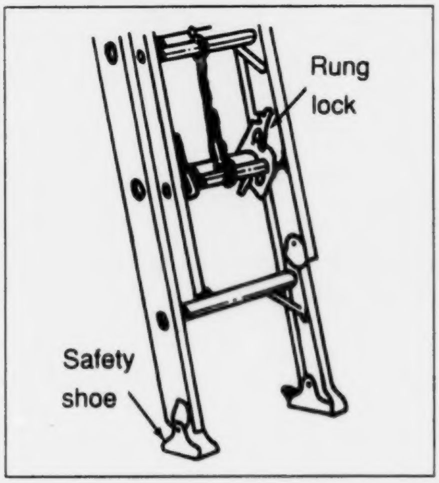
Note: Get help in carrying and raising heavy or long ladders.

Figure 19


36" above landing
Distance to top bearing point
4
About one fourth the distance to the top bearing point
1

h. Use rung locks to secure the sections of extension ladders. (Figure 20)

Figure 20


Rung lock
Safety shoe

i. Place top of extension and straight ladders at least three rungs above the work.

Information Sheet

j. Get a helper to heel straight or extension ladders (Figures 21 and 22).

Figure 21

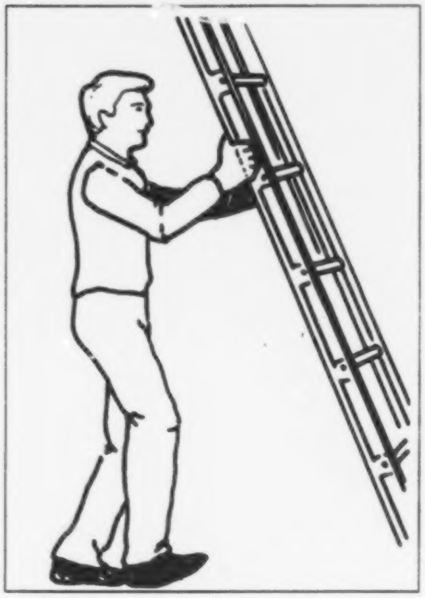
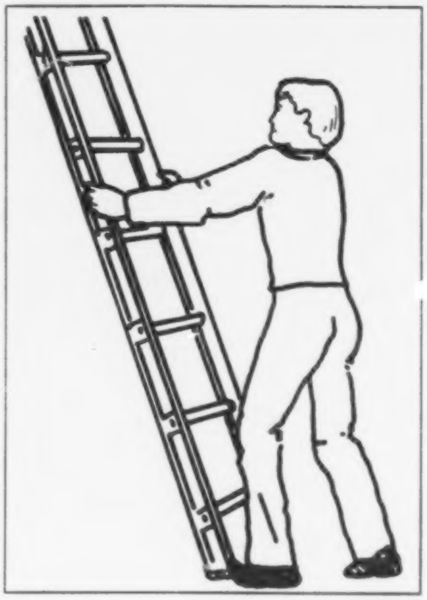


Figure 22



k. Face the ladder when climbing up and down.

l. Never stand on the top rung/step.

m. Do not overextend your reach while on the ladder; descend the ladder and reposition it instead.

n. Allow only one person on the ladder at a time.

o. Do not use ladders for makeshift scaffolds.

p. Store ladders securely when not in use.

21. Safety guidelines for using scaffolds

a. Never climb a scaffold unless all four scaffold legs are on the ground.

b. Secure scaffold wheel locks before climbing.

c. Get help when assembling the scaffold.

d. Never ride the scaffold when it is being moved.

e. Always use proper planks when assembling.

f. Always read manufacturer's instructions before constructing scaffolds.

Information Sheet

22. Safety guidelines for using power lifts

a. Never lift over the weight-rated capacity of the lift.

b. Operate lift on smooth surfaces if possible.

c. Always check for objects in the pathway.

d. Never put arms or legs in lift.

e. Always use caution when moving lift.

23. General steps for handling any emergency situation

a. **Step 1:** Determine the type of emergency.

b. **Step 2:** Notify the appropriate medical or law-enforcement authority.

Examples: Ambulance, fire department, police

c. **Step 3:** Notify your supervisor.

d. **Step 4:** Provide basic first aid, or seek assistance from others until proper authorities arrive.

24. General guidelines for first aid emergencies

a. Before administering first aid, always have a reason for what you do.

b. Reassure the injured person that everything possible is being done.

Note: Hearing the concerned voice of a co-worker is psychologically comforting to an injured person and can actually lessen the degree of traumatic shock.

c. Make accurate notes about the accident, including the victim's name, the time, place, cause or nature of the accident, and any first aid that was administered.

d. Do not notify the victim's family; this is the responsibility of the school, the job site supervisor, or the medical facility.

e. Report all accidents and injuries to your instructor or job site supervisor, no matter how minor they may seem.

Information Sheet

25. Descriptions of basic first aid procedures for various emergency situations

Note: In the event of a severe injury or illness, notify your supervisor, call an ambulance, paramedics, or a doctor, and give the victim basic first aid until help arrives.

a. **Bleeding**

- *Severe*—Apply pressure dressing or manual pressure to wound.
- *Minor*—Apply antiseptic solution and dress with sterile bandages.

b. **Burns**

- *Third-degree*—Cool with a damp compress and then cover with a dry, sterile dressing; cover victim with a blanket to prevent loss of body heat.
- *Second-degree*—Cool with a damp compress—taking care not to break blisters—and then cover with a dry, sterile dressing to prevent infection.
- *First-degree*—Hold under cold water; apply dry, sterile dressing.
- *Chemical*—Flush skin thoroughly with clean water.
- *Electrical*—Locate both the entrance and exit burns, and treat as for a third-degree burn.

c. **Eye injury**

- *Minor*—Have the victim close his or her eyes; put a piece of moist cotton over the closed lid; place a bandage over the cotton; get the victim to a doctor as soon as possible.
- *More severe injury*—Apply a sterile dressing, bandage *loosely*, and get medical help immediately.

  Note: Never permit the victim of an eye injury to rub his or her eye. Even though damage may be confined to one eye, it is sometimes best to bandage both eyes with a sterile dressing so the victim will not have a tendency to move the damaged eye.

- *Chemical injury*—Flush eyes immediately at an eye-flushing station, or use a bottled, portable flushing solution; then seek immediate medical assistance.

Information Sheet

d. **Traumatic shock**

Note: Traumatic shock may occur with any type of injury. Even though the injury itself may not be serious enough to cause death, death may occur from traumatic shock resulting from an injury.

- Recognize the signs and symptoms of traumatic shock:

  Early stages

  — Pale or bluish skin that is cool to the touch
  — Moist, clammy skin if perspiration has occurred
  — General weakness
  — Rapid, weak pulse
  — Rapid, shallow, possibly irregular breathing
  — Restlessness or anxiety
  — Vomiting or nausea
  — Excessive thirst

  Late stages

  — An attitude of not caring
  — Unresponsiveness
  — Sunken eyes with dilated pupils
  — Spotty or mottled appearance of skin; bluish color to lips and nailbeds
  — Low body temperature; cool, clammy skin
  — Loss of consciousness leading to death if untreated

- Lay victim down.

- Elevate victim's legs slightly.

- Cover to prevent loss of body heat.

e. **Falls**

- *Head injury*—Lay victim flat; control bleeding.

- *Less severe falls*—Check for injury and provide first aid as appropriate; do not move victim—or allow victim to move—if a neck or back injury is suspected.

Information Sheet

f. **Choking**

- Recognize the signs and symptoms of choking:
  - — Victim clutches throat (universal signal of choking)
  - — Victim has trouble speaking or breathing
  - — Skin turns pale or bluish
  - — Victim loses consciousness
- Perform the Heimlich maneuver.

g. **Heart attack**

- Recognize the signs and symptoms of heart attack:
  - — Chest pain that may radiate to the arms, neck, jaw, and upper back

    Note: Chest pain is the most important symptom of heart attack. It is reported in 80 to 90 percent of heart-attack victims.

  - — Profuse sweating and chills
  - — Nausea and vomiting
  - — Difficulty and pain in breathing
  - — Weakness
  - — Apprehension

    Note: A victim of heart attack will often feel as though he or she is going to die.

- Help victim to a less painful position.
- Loosen victim's clothing around the neck and midriff.
- Apply CPR if required and you are qualified.

h. **Electrical accident**

- Do **not** provide any medical assistance until all electrical current has been shut off.

Caution: If the victim is still in contact with a live electrical hazard, do not endanger yourself by touching the victim, metal objects, water, or the wet ground. You may well become a victim yourself as the current passes into your body.

Information Sheet

- Administer CPR if necessary.
- Treat for traumatic shock.
- Treat for electrical burn.

  Note: Always look for both an entrance wound and an exit wound with an electrical burn. Both may resemble a bull's-eye consisting of a central charred zone, a middle zone of gray tissue, and an outer red zone.

i. **Heat exhaustion**

- Recognize the signs and symptoms of heat exhaustion:
  - Profuse perspiration
  - Pale, clammy skin
  - Rapid, weak pulse
  - Rapid, shallow breathing
- Immediately move victim to a cool place.
- Lay victim flat.
- Elevate victim's feet slightly.
- Remove as much of victim's clothes as possible.
- Sponge victim with cool water.

j. **Heat stroke**

Note: Heat stroke is a true emergency. Act quickly or the victim will suffer brain damage or death.

- Recognize the signs and symptoms of heat stroke:
  - Little or no perspiration
  - Hot, flushed skin
  - Rapid, weak pulse
  - Rapid, shallow breathing
- Move victim to a cool location.
- Cool victim as quickly as possible.

  Note: Do not take time to remove victim's clothes until after initial cooling, such as spraying the victim with a garden hose or immersing him or her in water.

- Rub ice on victim's extremities.

Information Sheet

k. **Bee stings**

- *Ordinary reaction*
  - Scrape stinger sideways away from wound.

    Note: Never pinch the stinger to remove it as this releases more toxin into the victim's system.
  - Wash wound with soap and water.
  - Apply ice to reduce swelling.
- *Allergic reaction*

  Note: A victim with an allergic reaction to a bee sting is suffering from anaphylactic shock and needs prompt treatment with epinephrine by injection or inhalation.
  - If possible, immediately transport victim to a hospital or doctor's office.

    Note: Have someone call ahead to notify the party of the situation and your planned arrival.
  - If transportation is not immediately available, lay victim down or help the victim to a position in which he or she can breathe more easily.
  - Elevate victim's legs if possible.
  - While waiting for emergency help, remove the stinger and perform first-aid actions as for an ordinary sting.

l. **Seizure**

- Help victim lie on the ground or floor if possible.
- Do not try to restrain victim.
- Clear area of hard or dangerous objects to protect the victim from self-injury.
- Remove victim's eyeglasses, if applicable, and loosen clothing in the head and neck area.
- Turn victim to the side to allow saliva to drain from the mouth.
- Transport victim to a hospital or doctor's office after seizure has passed.

General Safety and First Aid
Unit 2

Student Supplement 1—Complete a Student Safety Pledge Form

______________________________, who is enrolled in Vocational ____________________

______________________________, will as a part of his/her shop experience, operate machines, providing that the parent or guardian gives written permission.

It is important that each student be given proper instruction, both in the use of the equipment and in correct safety procedures concerning it, before being allowed to operate it. The student must assume responsibility for following safe practices, and we therefore ask that the student subscribe to the following safety pledge.

I promise to follow all safety rules for the shop.

I promise never to use a machine without first having permission from the instructor.

I will not ask permission to use a particular machine unless I have been instructed in its use, and have made 100% on the safety test for that machine.

I will report any accident or injury to the teacher immediately.

Date ________________________ Student's signature ______________________________

I hereby give my consent to allow my son or daughter to operate all machines and equipment necessary in carrying out the requirements of the course in which he or she is enrolled.

Date ________________________ Parent's signature ______ ________________________

Parents are cordially invited to visit the shop to inspect the machines and to see them in operation.

General Safety and First Aid
Unit 2

Student Supplement 2—Guidelines for Interpreting Material Safety Data Sheets

Living in the modern world, you probably are aware that the use of chemicals offers convenience and progress at home and work. Naturally, you want to avoid dangerous overexposure to chemicals, especially on the job. Such overexposure is possible no matter where you work, even in an office or light industry.

Your company's hazard communications, or HazCom, program was created to protect your health and safety. Three important elements are at the heart of your HazCom program: warning labels on containers, training on the safe use and handling of chemicals, and material safety data sheets (MSDSs).

What is on a MSDS

MSDSs are printed pages that give you all the critical information you need about how to use, transport, and store chemicals in order to protect yourself, as well as what to do in case of emergencies and overexposure. Information on MSDSs includes:

- The chemical's name or names
- Name, address, and phone number of the manufacturer
- List of the chemical's ingredients
- Permissible exposure limits (PEL) or threshold limit value (TLV)
- What conditions or other substances will cause the chemical to catch fire, explode, melt, or turn into dangerous gases
- How the chemical usually looks and smells
- How to put out a fire involving the chemical
- What to do if the chemical spills or leaks
- How to prevent dangerous exposure
- Health hazards such as skin irritant or cancer-causing agent
- Symptoms of overexposure
- What to do if you are overexposed
- When the MSDS was prepared

The information for each chemical's MSDS is put together by the manufacturer or distributor for that chemical. The sheets often look different from each other, but they still provide the same information. The law requires your employer to keep MSDSs up to date and to send the MSDS to your doctor or designated representative if you request it.

Where the MSDS is kept

MSDSs must be readily accessible to employees—a posted sign may tell you where, and you can also find out by reading your company's written HazCom program. If you are not sure where to find MSDSs, your supervisor or your company's HazCom contact will make them available to you. It is the law.

Student Supplement 2

When to read a MSDS

You should always read the MSDS *before* you begin a job using a chemical. Even if you have used the chemical before, the manufacturer may have changed its formula, which may change the steps you should take to protect yourself. Taking proper precautions listed on the MSDS, such as wearing a respirator, can prevent serious long-term illnesses.

If you do not understand something on the MSDS, or have questions about your company's HazCom program, ask your supervisor or company contact. Your company knows that HazCom works best if you are fully informed and involved.

How to read a MSDS

The material safety data sheet, or MSDS, is written information that can help protect you from overexposure to chemicals you find on the job. The MSDS is part of your company's hazard communications program. Each company can design its own MSDS form, and the sections may be in a different order. But, the basic kinds of information on any MSDS will be the same.

Chemical name (see Figure 1). Lists the identity of the substance (the name on the label), date the MSDS was prepared, the name and address of the manufacturer, and usually a phone number for emergencies and more information.

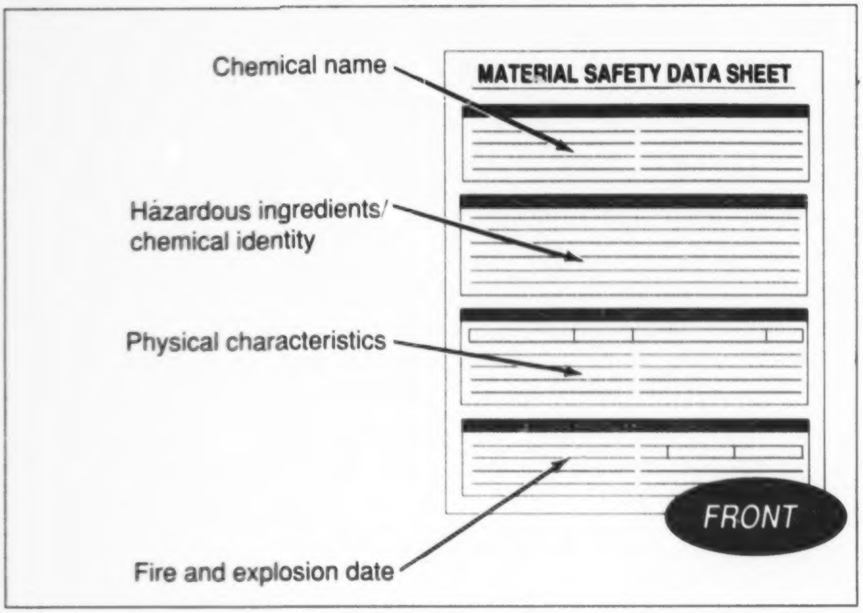
Hazardous ingredients/chemical identity (see Figure 1). Includes names of substances in the chemical that might be dangerous, and lists safety exposure limits such as permissible exposure limit or PEL (set by OSHA) or the threshold value limit or TVL. Also lists common names for the chemical.

Physical characteristics (see Figure 1). Describes many physical qualities of the chemical, and lets you know what is usual or safe. For example, how the chemical looks and smells; boiling and melting temperatures (important in case a chemical might become a gas you could breathe); evaporation rate (known as *percent volatile*); how easily the chemical dissolves; and how heavy it is (this tells you if it will sink, float, or dissolve in water).

Fire and explosion data (see Figure 1). Tells you the lowest temperature at which the chemical could catch fire (flash point). Lets you know if it is flammable (catches fire below 100°F) or combustible (catches fire above 100°F). Lists the best way to put out a fire involving that chemical.

Student Supplement 2

Figure 1



Reactivity (see Figure 2). Describes what happens if this chemical comes in contact with air, water, or other chemicals. Describes conditions (like heat) or materials (like water) that can cause the chemical to react by burning, exploding, or releasing dangerous vapors. The chemical is called "incompatible" or "unstable" with these conditions or substances.

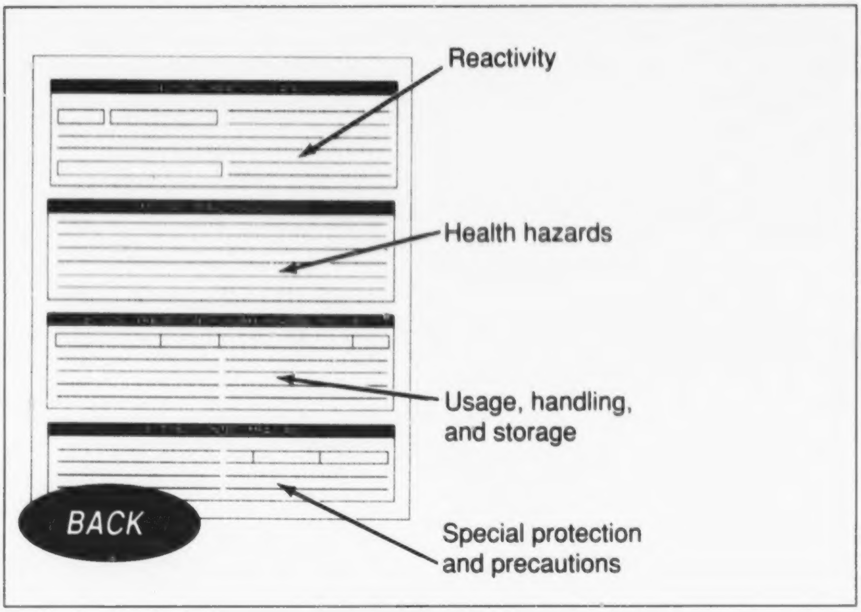
Health hazards (see Figure 2). Lists ways the chemical might enter your body, like splashing on your skin or being breathed in as vapor, as well as possible symptoms of overexposure. Lets you know if overexposure might make existing medical conditions worse, and describes emergency first aid procedures.

Usage, handling, and storage (see Figure 2). Describes how to clean up an accidental spill, leak, or release, including special procedures. Tells you how to handle, store, and dispose of chemicals safely. Remember, if there is an accident, notify your supervisor immediately. Take care of it yourself only if you are trained to do so and are wearing the proper equipment.

Special protection and precautions (see Figure 2). Explains special personal protective equipment (PPE) and other equipment to use when working with the chemical, special procedures, extra health or safety information, signs that should be posted, and other information not covered in other sections.

Student Supplement 2

Figure 2


Reactivity
Health hazards
Usage, handling, and storage
BACK
Special protection and precautions

Terms and abbreviations used on MSDSs

The following terms and abbreviations will help you interpret material safety data sheets.

- **TLV**—Threshold limit value; a time-weighted average concentration *under which* most people can work consistently for 8 hours a day, day after day with no harmful effects
- **Ceiling**—Uppermost limit
- **ACGIH**—American Conference of Governmental Industrial Hygienists
- **OSHA**—Occupational Safety and Health Act
- **PEL**—Permissible exposure limit; the maximum time-weighted concentration *at which* 95 percent of exposed, healthy adults suffer no adverse effects over a 40-hour week
- **ppm**—Parts per million
- **STEL**—Short-time exposure limit; a 15-minute, time-weighted average that should not be exceeded at any time during a workday. Exposures at STEL should not be longer than 15 minutes and should not be repeated more than four times a day with at least 60 minutes between exposures

Student Supplement 2

- **IDLH**—Immediately dangerous to life and health; material *at* or *above* this level poses an immediate hazard to life or produces immediate, irreversible, debilitating effects
- **LEL**—Lower explosive limit; below the flammability range (too lean to burn)
- **UEL**—Upper explosive limit; above the flammability range (too rich to burn)

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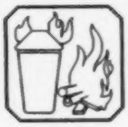
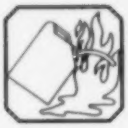
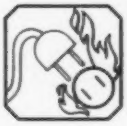
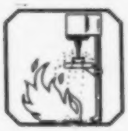
General Safety and First Aid
Unit 2

Student Supplement 3—Using Portable Fire Extinguishers

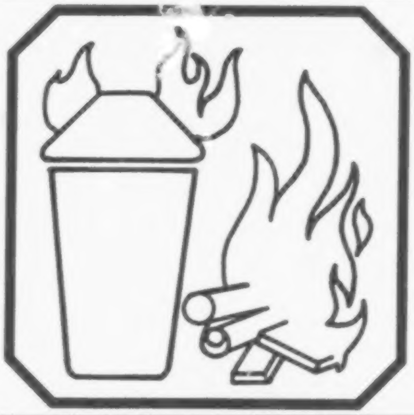
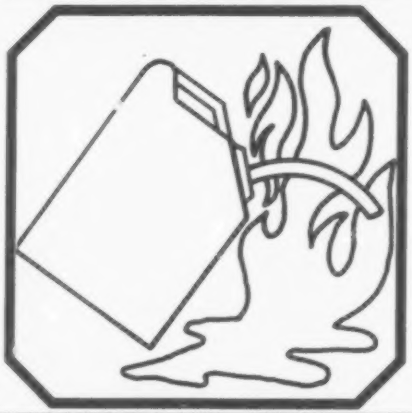
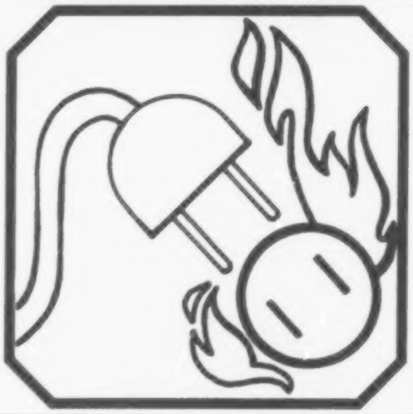
All portable fire extinguishers are labeled with picture and shape symbols. Each of the shape symbols (triangle, square, circle, and star) contains the letter of the fire class for which the extinguisher is effective. The picture symbols not only illustrate what type(s) of fire the extinguisher may be used on, but also tell what class(es) of fire the extinguisher should **not** be used on. All of this information, as well as directions for using the extinguisher, are also printed on the extinguisher. However, when a fire is discovered, speed is important, and, as the saying goes, "a picture is worth a thousand words." You should learn to be able to glance at the symbols on an extinguisher and know immediately whether the extinguisher is appropriate for the fire on hand.

Below are examples of fire-class shape symbols and their meanings, and examples of extinguisher picture symbols and their meanings.

Class A	**Class B**
(Green) ▲ A • Ordinary combustibles 	(Red) ■ B • Flammable liquids and gases 
Class C	**Class D**
(Blue) ● C • Live electrical equipment 	(Yellow) ★ D • Combustible metals 

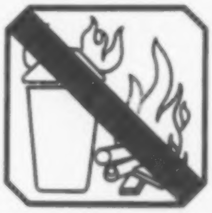
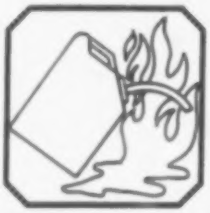
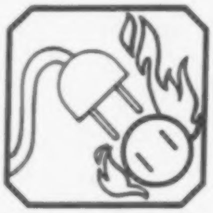
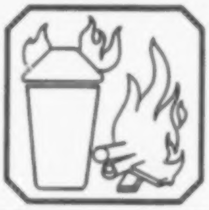
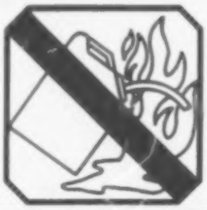
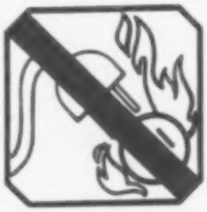
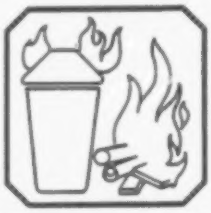
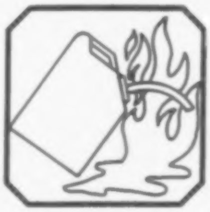
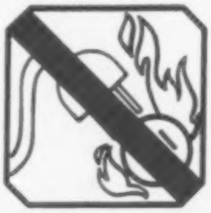
General Safety and First Aid
Unit 2

Student Supplement 4—Extinguisher Markings for Extinguishers Suitable for Use on Class A, B, or C Fires

Ordinary A combustibles (Green)	
Flammable B liquids (Red)	
Electrical C equipment (Blue)	

General Safety and First Aid
Unit 2

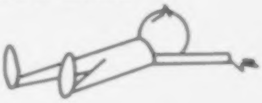
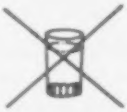
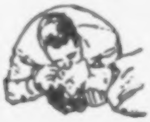
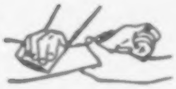
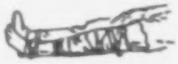
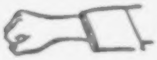
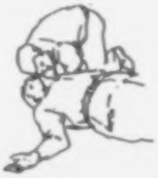
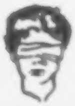
Student Supplement 5—Extinguisher Markings Indicating Extinguishers Unsuitable for Use on Class A, B, or C Fires

			Picture symbols for extinguishers suitable for Class B and C fires, but **not** for Class A fires.
			Picture symbols for extinguishers suitable for Class A fires, but **not** for Class B and C fires.
			Picture symbols for extinguishers suitable for Class A and B fires, but **not** for Class C fires.

General Safety and First Aid
Unit 2

Student Supplement 6—General Directions for Giving First Aid

American Red Cross

Keep the injured person lying down.  Do not give liquids to an unconscious person.  Restart breathing with mouth-to-mouth artificial respiration.  Control bleeding by pressing on the wound.  Dilute swallowed poisons and call the Poison Control Center. Keep broken bones from moving.  Cover burns with thick layers of cloth.  Keep heart-attack cases quiet and give cardiopulmonary resuscitation (CPR) if it is necessary  and if you have been trained. Keep a fainting victim lying flat. For eye injuries, pad and bandage both eyes.  Always call a doctor.

For more information about these and other lifesaving techniques, contact your Red Cross chapter.

American Red Cross poster

Courtesy of the American Red Cross, Washington, D.C.

General Safety and First Aid
Unit 2

Assignment Sheet 1—Interpret a Material Safety Data Sheet

Name ______________________ Overall rating __________

Evaluation criteria	**Rating**
Directions followed	______
All answers correct per Answers to Assignment Sheet 1	______

Directions: Review the material in Objective 4 of the information sheet, and locate and study the information presented in Student Supplement 2, "Guidelines for Interpreting Material Safety Data Sheets."

Use the MSDS at the end of this assignment sheet to answer the following questions. Write your answers on the blanks provided below each item.

MSDS—Gel Graffiti®

A. What is this product used for?

____

B. What is the main ingredient in this product?

____

C. What does this product look like?

____

D. What percentage of this product is volatile (capable of exploding)?

____

E. What extinguishing agents should be used on fires created by this product?

____

F. What may happen if aerosol containers of this product are exposed to temperatures higher than 130°F?

____

Assignment Sheet 1

G. What is the TLV for this product?

H. Are any of the ingredients in this product suspected of causing cancer? Explain.

I. What is the primary way in which this product enters the body?

J. What are the symptoms of overexposure to this product?

K. What first-aid measure should **not** be taken if this product is ingested?

L. What conditions should be avoided when using this product?

M. What products should you avoid using with this product?

N. How should you dispose of this product?

Assignment Sheet 1

O. What special protective measures should you take when using this product?

____

____

____

P. What special hygiene precautions should you take when using this product?

____

____

Assignment Sheet 1

JCLE035 01/003/0020
CLEANER, GRAFFITI GEL
3-15-89

HAZARDOUS COMMUNICATION GUIDE

Material Safety Data Sheet

N/A = Not Applicable
N/D = No Data
N/E = Not Established

Supersedes: *10/20/86*

I. General Information

Date Revised: *12/9/88*

Chemical Name & Synonyms
N/A

Chemical Family
Engine degreaser (gelled)

Proper DOT Shipping Name
Consumer commodity 48580 Sub 3

Manufacturer
Crain Chemical Co., Inc.

Manufacturer's Address
P.O. Box 540995, Dallas, TX 75354

Trade Name & Synonyms
GEL GRAFFITI

Formula
N/A

DOT Hazard Classification
ORM-D

Manufacturer's Phone Number
214/358-3301

Chemtrec Phone Number
1-800-424-9300

II. Ingredients

Principal Hazardous Components	Percent	Threshold Limit Value (units)	
		OSHA	ACGIH
Ethanol *CAS# 64-17-5*	*N/A*	*1000 ppm*	*1000 ppm*
Aromatic Hydrocarbon *CAS# 64742-06-9*	*N/A*	*100 ppm*	*100 ppm*
Chlorinated Hydrocarbon *CAS# 75-09-2*	*N/A*	*500 ppm*	*100 ppm*
Glycol Ethers *CAS# 111-76-2*	*N/A*	*50 ppm*	*25 ppm*

III. Physical Data

Boiling Point (°F)
N/A

Vapor Pressure (mm Hg.)
N/D

Vapor Density (Air = 1)
N/E

Solubility in Water
N/A

Appearance & Odor
Opaque, white gel/characteristic odor

Specific Gravity (H_2O = 1)
N/A

Percent Volatile By Volume (%)
77

Evaporation Rate (____ = 1)
N/A

pH
N/A

IV. Fire & Explosion Hazard Data

Flash Point (Test Method)
Flame projection 18" plus

Flammable Limits
Flammable

Extinguishing Media
CO_2, Foam

Special Fire Fighting Procedures
Self-contained breathing apparatus

Auto Ignition Temperature
N/E

LEL
N/E

UEL
N/E

Unusual Fire & Explosion Hazards
Do not expose aerosols to temperatures above 130°F or the container may rupture.

Assignment Sheet 1

JCLE035 01/003/0020

HAZARDOUS COMMUNICATION GUIDE

V. Health Hazard Data

Threshold Limit Value	OSHA Threshold Limit Value	ACGIH Threshold Limit Value
50 ppm	*See Section II*	*See Section II*

Carcinogen - NTP Program	Carcinogen - IARC Program
Chlorinated hydrocarbon (animal data only)	*Same as (NTP)*

Symptoms of Exposure

Headaches, dizziness, irritation, burning (eyes), nausea, asphyxia and possible chemical pneumonitis if aspirated into lungs.

Medical Conditions Aggravated by Exposure

May aggravate existing eye, skin, or upper respiratory conditions.

Primary Route(s) of Entry

Inhalation

Emergency First Aid

Eyes: Flush with water for 15 minutes. If irritated, see physician. Skin: Wash with soap and water. If irritated, see physician. Inhalation: Move to fresh air. Resuscitate if necessary. Get medical aid. Ingestion: Do NOT induce vomiting. Call physician immediately.

VI. Reactivity Data

Stability		Unstable	Conditions to Avoid *Heat, sparks, welding arcs, open flames*
	X	Stable	Materials to Avoid *Strong oxidizing agents*
Incompatibility			
Hazardous Polymerization		May Occur	Conditions to Avoid *None known*
	X	Will Not Occur	

Hazardous Decomposition Products

CO_2, CO, HCL, Small amounts of phosgene and chlorine

VII. Environmental Protection Procedures

Spill Response

Absorb with suitable medium. Incinerate or land fill according to local, state, or federal regulations. Do not flush to sewer.

Waste Disposal Method

Aerosol cans, when vented to atmospheric pressure through normal use, pose no disposal hazards.

VIII. Special Protection Information

Eye Protection *Safety glasses recommended*	Skin Protection *Neoprene gloves recommended*
Respiratory Protection (Specific Type) *If vapor conc. exceeds TLV, use respirator approved by U.S. Bureau of Mines for organic vapor.*	Ventilation Recommended *Adequate ventilation to keep vapor concentration below TLV.*
Other Protection *None*	

Page *2* of *3*

Assignment Sheet 1

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HAZARDOUS COMMUNICATION GUIDE

IX. Special Precautions

Hygienic Practices in Handling & Storage

Wash with soap and water before handling food. Do not puncture or incinerate containers. Do not store at temperatures above 130°F.

Precautions For Repair & Maintenance Of Contaminated Equipment

Remove all ignition sources i.e., heat, sparks, open flames, etc.

Other Precautions

Avoid food contamination. Keep out of reach of children. Remove ignition sources. Avoid breathing vapors.

General Safety and First Aid
Unit 2

Assignment Sheet 2—Draw a Layout of Your School Shop and Apply the Safety Color Code

Name ______________________________ Overall rating __________

Evaluation criteria	**Rating**
Included all required items	______
All items correctly color-coded	______
Layout neat and legible	______

Directions: Draw a layout of your school shop including all machines, workbenches, tools, first aid kit, and fire prevention equipment. Use the federal safety color code to identify equipment, hazards, safety features, and exposed parts that could cause accidents.

General Safety and First Aid
Unit 2

Assignment Sheet 3—Interpret Portable Fire-Extinguisher Symbols

Name ______________________________ Overall rating __________

Evaluation criteria	**Rating**
Directions followed	______
All answers correct per Answers to Assignment Sheet 3	______

Introduction: When a fire occurs, it is very important not only to be able to size-up and identify the type of fire, but also to choose an extinguisher that will be effective in putting out the fire.

Directions: Review the material presented in Objective 14 of the information sheet, and locate and study the information presented in Student Supplements 3 through 5.

Next, read and follow the directions with each item below.

A. Match extinguisher picture symbols with the extinguisher's intended applications. Write the correct numbers on the blanks.

______ 1. Class A and B fires but not Class C fires

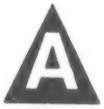
______ 2. Flammable liquids

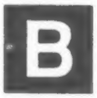
______ 3. Class B and C fires but not Class A fires

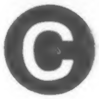
______ 4. Ordinary combustibles

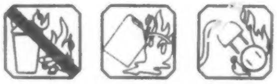
______ 5. Class A fires but not Class B and C fires

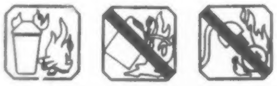
______ 6. Electrical equipment

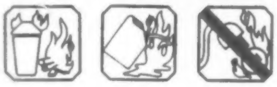
a. 

b. 

c. 

d. 

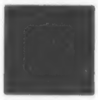
e. 

f. 

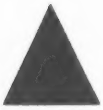
Assignment Sheet 3

B. Write on the blank the correct fire-class letter that would appear in the center of each of the following extinguisher symbol shapes. Below each shape write the color associated with the shape.

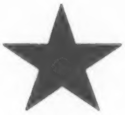
______ 1.



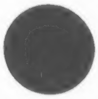
______ 2.



______ 3.



______ 4.



C. Complete fire-extinguisher general operating instructions that follow the letters P-A-S-S.

1. **P** ____________________

2. **A** ____________________

3. **S** ____________________

4. **S** ____________________

General Safety and First Aid
Unit 2

Assignment Sheet 4—Identify and Correct Safety Violations

Name ______________________________ Overall rating __________

Evaluation criteria	**Rating**
Five of six safety violations identified	______
Five of six corrective measures described	______

Directions: The following scenario relates unsafe acts that may be found in the classroom. List the safety violations and corrective measures that should have been taken to prevent them.

Scenario

The morning class was loading materials and equipment for their school project house. John, one of the students, went to the tool room and got the ½-inch drill motor that had a red tag attached to the power cord. John noticed there was a stripped wire on the drill, but he did not think it was that bad. John pulled the red tag off the drill and threw it in the trash. Then John went to the tape cabinet to find some electrical tape. The bell rang, so John placed the drill with the other tools and went to catch the bus.

When the afternoon class arrived, they finished loading the tools and materials onto the bus and went to the project house. Jim was asigned to drill out the house. He picked up the drill that John had left with the other tools, and started to drill. The plumbing students were also working in the house testing water lines, and the floor was covered with water. While drilling in the bathroom, Jim pulled the drill cord through the water and received a severe electrical shock.

A. List the safety violations.

____

____

____

____

____

____

Assignment Sheet 2

B. List the corrective measures that should have been taken.

General Safety and First Aid
Unit 2

Job Sheet 1—Operate a Fire Extinguisher

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Extinguisher was carried properly.	______
User was within stream reach of fire.	______
P-A-S-S sequence was followed.	______
Fire was completely extinguished.	______

Note: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the above criteria.

Introduction: Using a portable fire extinguisher properly requires more than simple manipulation. You must always size up the fire and decide whether it can be extinguished with an extinguisher. If the fire is too large or too smoky, call the fire department. If the fire is small enough to be extinguished with an extinguisher, always fight it with your back to a means of escape.

A. Equipment and materials

Portable fire extinguisher suitable for a Class A fire
Small Class A fire in clear, safe area
Charged hose (hose hooked up to a water source and with water in the hose) or another secondary means of extinguishment for backup

Caution: This procedure should only be performed outdoors on a windless day, and only under the direct supervision of your instructor.

B. Procedure

☐ 1. Pick up the fire extinguisher by its handle.

Note: *All* modern fire extinguishers are designed to be used in an *upright* position.

Job Sheet 1

☐ 2. Read the fire extinguisher label to determine proper stream reach.

Note: *Stream reach* is the distance the extinguishing agent is propelled. Stream reach varies with extinguisher, and may range from 3 to over 20 feet. Normally, the smaller the extinguisher, the shorter the stream reach.

☐ 3. Walk—do not run—to within stream reach of the fire.

☐ 4. **Pull** the pin at the top of the extinguisher that keeps the handle from being pressed.

Note: Pulling the pin automatically breaks the plastic or thin wire inspection band.

☐ 5. **Aim** the nozzle toward the fire, first releasing it from its clip if applicable.

☐ 6. **Squeeze** the discharge handle (above the carrying handle) to release the extinguishing agent.

Note: The discharge handle can be released at any time to stop the discharge.

☐ 7. **Sweep** the nozzle back and forth at the base of the flames.

☐ 8. After the fire appears to be out, probe for remaining hot spots.

☐ 9. Make sure the fire is out by extinguishing any hot spots.

Evaluator's comments: ____

____

____

General Safety and First Aid
Unit 2

Job Sheet 2—Lift a Heavy Object Properly

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation criteria	**Rating**
Load was safely lifted	______
Load was safely carried and set down	______

Note: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the above criteria.

Introduction: The number-one worker injury in America today is back strain or injury. Most of these injuries come from trying to lift an object that is too heavy or from lifting an object improperly. It is very important, therefore, that you learn to assess the weight of a load to be lifted, and either get help to lift the load or lift the load properly, using your leg muscles, not your back.

A. Equipment and materials

Large, heavy box
Gloves
Lower-back support belt

B. Procedure

☐ 1. Put on gloves and lower-back support belt.

☐ 2. Size up the load.

☐ 3. Place your feet close to the object and 8 to 12 inches apart for good balance.

☐ 4. Bend your knees to a degree that is comfortable.

☐ 5. Grip the box firmly with both hands.

Job Sheet 2

☐ 6. Keeping your back straight and using your leg muscles, lift the box to waist height and hold close to your body.

> **Caution: Do not make any turning or twisting motions until the lift is complete.**

☐ 7. Turn by changing foot position, making sure that your path is clear.

☐ 8. Carry the box to the new location, using a normal walking gait and keeping your view unobstructed.

☐ 9. Reverse the lifting procedure to set the box down, taking care to bend your knees, keep your back straight, and avoid setting the box on your fingers or feet.

Evaluator's comments: ____________________

____

____

General Safety and First Aid
Unit 2

Job Sheet 3—Place and Climb a Ladder Safely

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	Rating
Ladder was picked up correctly and safely.	______
Ladder was carried correctly and safely.	______
Ladder was placed correctly and safely (1 foot from wall for every 4 feet of ladder height; at least three rungs above work)	______
Ladder was climbed and descended safely.	______

Note: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the above criteria.

Introduction: To avoid falls and strains, correct and thoughtful placement of a ladder is very important. The ladder should be lifted correctly, and placed so that its base is at least a foot from the wall for each 4 feet of height. The ladder should also be placed close enough to the work so that the user does not need to stretch to reach the work.

A. Equipment and materials

One 12-foot straight ladder
Class member to heel ladder

B. Procedure

☐ 1. Kneel beside the ladder, facing its top at about midpoint, knee closest to ladder on the ground.

☐ 2. Reach across the ladder and grasp the rung opposite close to the far siderail.

☐ 3. Stand up—using your legs, not your back.

☐ 4. As you stand, pivot toward the other end of the ladder, slip your free arm between convenient rungs, and lift the ladder so that its top beam rests on your shoulder.

Job Sheet 3

☐ 5. Carry the ladder to the work area, taking care to avoid bumping it into anything or anyone.

☐ 6. Check the work area for overhead electrical obstructions.

☐ 7. Slip the ladder from your shoulder, and rest it against the wall.

8. Adjust the ladder placement:
   - ☐ a. Shoes are secure on a flat surface
   - ☐ b. Base is approximately 1 foot from the wall for each 4 feet of working ladder height
   - ☐ c. Top of ladder is at least three rungs above the work

☐ 9. Ask a classmate to heel the ladder.

10. Climb the ladder to the work:
    - ☐ a. Facing the ladder,
    - ☐ b. Hands on rungs or siderails, and
    - ☐ c. Feet squarely on rungs.

11. Descend the ladder:
    - ☐ a. Facing the ladder,
    - ☐ b. Hands on rungs or siderails, and
    - ☐ c. Feet squarely on rungs.

Evaluator's comments: ______________________________

____

____

Electrical Safety
Unit 3

Objective Sheet

Unit Objective

After completing this unit, the student should be able to identify electrical hazards and practice basic electrical safety. The student should demonstrate these competencies by completing the assignment sheets and scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to electrical safety with their correct definitions.
2. List major causes of electrical accidents.
3. Select from a list basic electrical safety practices.
4. Complete statements concerning electrical fire prevention practices.
5. Select true statements concerning safety practices around live circuits.
6. Select true statements concerning proper grounding.
7. List facts about the importance of the third wire.
8. Describe ground-fault circuit-interrupters.
9. List instances when lockout devices should be used.
10. Select words to complete statements about electrical shock.
11. Select facts about treating a victim of electrical shock.
12. Identify and describe safety violations. (Assignment Sheet 1)
13. Solve problems concerning electrical safety practices. (Assignment Sheet 2)

Electrical Safety
Unit 3

Suggested Activities

Instructional Plan

Preparation

1. Read the unit carefully and plan for instruction. Study the specific objectives to determine the order in which you will present them.
2. Review Teaching Suggestions section that follows. Plan for classroom activities.
3. Plan your presentation to take advantage of student learning styles and to accommodate special needs students.
4. Make transparencies from the transparency masters included with this unit. The masters appear in the teacher guide only and are intended to be used with the following objectives:

   TM 1—Fire Prevention (Objective 4)
   TM 2—Electric Shock Versus Body Sensation (Objective 10)
   TM 3—Dangers of Rescue Procedures (Objective 11)
   TM 4—Dangers of Rescue Procedures (Continued) (Objective 11)

5. Obtain films, videotapes, and other resources to supplement instruction of this unit. See ordering information in the Suggested Supplemental Resources section that follows.
6. Develop teaching plan. Adjust for different learning styles.
7. Make copies of Unit Evaluation Form.

Delivery and Application

8. Provide students with unit of instruction.
9. Discuss unit and specific objectives.
10. Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic skills when applicable.
11. Discuss assignment sheets and schedule due dates. Review criteria for evaluation of these activities.

Suggested Activities

Evaluation

12. Discuss the use of the Unit Evaluation Form with students. Select and discuss the rating scale that will be used for student evaluation.

13. Make copies of the written test. Add or modify test questions as needed.

14. Give written test.

15. Compile assignment sheet ratings and written test scores on the Unit Evaluation Form. Include any additional assignments.

16. Reteach and retest as required.

Teaching Suggestions

Note: Skill areas appearing in boldface type in the Teaching Suggestions refer to the academic and workplace skills identified by the American Society for Training and Development (ASTD) and the U.S. Department of Labor. These have been adapted by MAVCC.

1. Demonstrate the proper use of lockout devices. Allow students to return your demonstration. Skill areas: **Observation of scientific principles, listening**

2. Demonstrate the function of a ground-fault circuit-interrupter. Skill area: **Observation of scientific principles, listening**

3. Have students survey the shop area for uses of ground-fault circuit-interrupters.

4. Show students how to work safely with live voltages. Skill areas: **Observation of scientific principles, listening**

5. Invite first aid personnel from the local Red Cross or a power supply company to demonstrate rescue procedures for victims of electrical shock. Skill area: **Listening**

6. Have students make shop safety posters related to electrical safety. Skill area: **Creative application**

7. Invite a member of your local Emergency Medical Service team to speak to the class on precautions that rescuers should take to avoid contaminated body fluids, hepatitis, and AIDS infection when administering first aid. Skill area: **Listening**

Suggested Activities

Resources Used in Developing This Unit

1. Early, Mark W., John M. Caloggero, and Richard H. Murray. *National Electrical Code 1993*. Quincy, MA: National Fire Protection Association, 1992.
2. Hartman, Lonnie. *Basic Electronics*. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1986.
3. *Safety in Electrical Maintenance*. Rockville, MD: NUS Training Corporation, A Halliburton Company.
4. Taylor, Mark. *Residential Wiring*. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1983.
5. Turner, J. Howard. *Understanding Electricity and Electrical Terms*. Athens, GA: American Association for Vocational Instructional Materials.

Suggested Supplemental Resources

Videotapes

1. Working safely with electricity series:
    - *Electricity Can Kill* (18 minutes)
    - *The Shock Emergency* (18 minutes)
    - *The Importance of Grounding* (16 minutes)
    - *Emergency Response* (16 minutes)

    Note: Order from Bergwall Productions, Inc., 540 Baltimore Pike, Chadds Ford, PA 19317
2. *Electrical Safety* (29 minutes)

    Note: Order from the Oklahoma Department of Vocational and Technical Education, Attn: Instructional Media Specialist, 1500 West Seventh Avenue, Stillwater, OK 74074-4364.
3. *The Path of Least Resistance* (16 minutes)

    Note: Order from Agency for Instructional Technology, Box A, Bloomington, IN 47402-0210.

Suggested Activities

Instructions for Evaluating Student Performance

When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in either the teacher guide or student manual. Then observe the student performing the procedure.

> Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily achieved the step(s) for each checkpoint area. If the student is unable to correctly complete the procedure, have the student review the materials and try again.
>
> Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria which have been provided as part of the job sheet. Complete the rating by assigning a point value to each criterion and by converting the point total to a percentage for grading. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) which best fits your program needs.

Option A

4 - Skilled—Can perform job with no additional training.
3 - Moderately skilled—Has performed job during training program; limited additional training may be required.
2 - Limited skill—Has performed job during training program; additional training is required to develop skill.
1 - Unskilled—Is familiar with process, but is unable to perform job.

Option B

Yes—Can perform job with no additional training.

No—Is unable to perform job satisfactorily.

Electrical Safety
Unit 3

Answers to Written Test

1.	a. 7	e. 11	h. 3	k. 9
	b. 9	f. 8	i. 2	l. 6
	c. 1	g. 10	j. 5	m. 4
	d. 13			

2. a. Rushed or distracted personnel (carelessness)
   b. Failure to verify that equipment was deenergized
   c. Misuse of tools or equipment

3. b, c, e, f, g, h, k, m, o

4. a. 1
   b. 3
   c. 2
   d. 4

5. a, e, f

6. a, b, e

7. Answer should include any three of the following:

   a. It is installed for personal protection.
   b. It provides an alternate path for current in case of short.
   c. It can save a person's life.

8. Description should include the following points:

   a. Are personal safety devices designed to protect individuals or equipment by deenergizing or tripping a circuit when current to ground reaches 0.0005 ampere
   b. Are required on 15- and 20-ampere receptacle outlets used for temporary power supply at construction sites
   c. Interrupt flow of current in substantially less time than a normal overcurrent device will

9. a. Use when more than one power source is present.
   b. Always use when hydraulic position could change.
   c. Always use when pneumatic position could change.
   d. Use to lock off all electrical devices before working on equipment.

Answers to Written Test

10. a. Voltage
    b. Current
    c. 10
    d. 1
    e. 100

11. a. 2
    b. 2
    c. 3
    d. 3
    e. 1
    f. 2
    g. 1
    h. 3

Electrical Safety
Unit 3

Written Test

Name ______________________________ Score ______________

1. Match terms related to electrical safety with their correct definitions. Write the correct numbers in the blanks. Definitions are continued on the next page.

______ a. Breaker or device designed to protect individuals and equipment by deenergizing or tripping a circuit when current to ground reaches 0.0005 ampere

______ b. A system by which equipment is powered by air

______ c. Unit of measure for electrical current or intensity of electron flow

______ d. Unit of measure for electrical pressure

______ e. Unit of measure for electrical resistance

______ f. One complete positive or negative cycle in an alternating current circuit

______ g. A type of surface or flush raceway designed to hold conductors and receptacles

______ h. A device that plugs into a receptacle and provides space for connection of two or more attachment plugs

______ i. Material through which electrons flow easily

______ j. Electrical point on any good conductor that is connected to a common chassis with zero relative voltage; usually conductors are connected to the earth

1. Ampere
2. Conductor
3. Cube tap
4. Current
5. Ground
6. Grounded
7. Ground-fault circuit-interrupter
8. Hertz
9. Hydraulic
10. Multi-outlet assembly
11. Ohm
12. Pneumatics
13. Volt

Written Test

______k. A system by which equipment is powered by liquid

______l. Connected to earth or to some conducting body that serves in place of the earth

______m. Electron flow through a conductor

2. List the major causes of electrical accidents.

a. ____

b. ____

c. ____

3. Select froma list basic electrical safety practices. Write an "X" before each correct safety practice.

______a. Because 110 volts is relatively low, some safety rules can be ignored.

______b. Watch out for electrical arcs; they can cause bad burns.

______c. Know where all emergency shutdown switches are located.

______d. Know that slight overloads are acceptable on some circuits.

______e. Never bypass a fuse.

______f. Always check a circuit for voltage before servicing.

______g. Be sure that all current-carrying electrical lines are well insulated.

______h. Watch for burned wires on electrical devices.

______i. Operate equipment only 5 percent beyond its rated capacity.

______j. Look for cold conductors in electrical systems.

______k. Work on live (energized) circuits only when absolutely necessary.

______l. Do not operate electrical parts when perspiring.

______m. Properly ground all electrical equipment and tools to prevent injury to the operator.

Written Test

______n. Never touch a conductor without first donning insulated or rubber boots.

______o. Do not make any adjustment or repairs to any electrical equipment until all power has been disconnected or the electrical breaker has been turned off.

______p. Always work alone when working with more than 50 volts.

4. Select words to correctly complete statements concerning electrical fire prevention practices. Write the correct numbers in the blanks.

______a. Use extension cords only within their ___.
    1. designated rating
    2. restricted ohm range
    3. recommended hertz cycle
    4. rated receptacle designation

______b. Never let multi-outlet assemblies or cube taps cause ___.
    1. arcing
    2. conductance
    3. overloads
    4. grounding

______c. Never use ___ or deteriorated extension cords.
    1. insulated
    2. frayed
    3. wrapped
    4. old

______d. Never tamper with ___ to change their current-carrying capacity.
    1. ground devices
    2. monitoring tools
    3. breaker boxes
    4. fuses

5. Select true statements concerning safety practices around live circuits. Write an"X" in the blank before each true statement.

______a. Use a reliable circuit tester or voltmeter to identify live circuits.

______b. Stand on a dry or, at most, a damp surface.

______c. Keep both hands on your work whenever possible.

Written Test

______d. Lay out your tools within easy reach of your work.

______e. Wear suitable insulated hand covering.

______f. Return all tools to your pouch as soon as you are through with them.

6. Select true statements concerning proper grounding. Write an "X" in the blank before each true statement.

   ______a. Always check electrical equipment for proper grounding before working on it.

   ______b. Proper grounding allows the fault current to clear the overcurrent device, thus providing safe operation.

   ______c. Properly grounded equipment provides a pathway for stray current through the operator's body.

   ______d. Loose wires that touch a case or housing in electrical equipment cannot cause an electrical shock if the equipment has not been properly grounded.

   ______e. Loose connections can be detected by heated or discolored conductors, a burning odor, or carbon tracking.

7. List facts about the importance of the third wire.

   a. ____

   b. ____

   c. ____

8. Describe ground-fault circuit-interrupters.

   a. ____

   ____

   b. ____

   ____

   c. ____

   ____

Written Test

9. List instances when lockout devices should be used.

   a. ______________________________

   b. ______________________________

   c. ______________________________

   d. ______________________________

10. Select words to complete statements about electrical shock. Circle the correct words.

    a. High (current, voltage) tends to knock the victim away from the circuit, thus minimizing exposure time.

    b. High (current, voltage) tends to cause the body to adhere to the circuit so that the victim cannot let go.

    c. At about (1,000, 10) milliamperes, the shock is severe enough to paralyze muscles, but a person may be able to let go of the conductor.

    d. At about (1, 10) milliamperes, a slight shock will be felt.

    e. At about (10, 100) milliamperes, the shock is usually fatal if it lasts 1 second or more.

11. Select facts about treating a victim of electrical shock. Write the correct numbers in the blanks.

    ______a. What is the first step in rescuing a victim of electrical shock?
    1. Treating electrical burn
    2. Deenergizing the power source
    3. Treating traumatic shock
    4. Restoring breathing and/or heartbeat

    ______b. As an extra precaution, and only after the electricity has been turned off, how should the victim of an electrical accident be moved?
    1. By pushing the victim with a foot encased in a leather-soled shoe
    2. By using a stick, rope, blanket, or other nonconductor to nudge or grasp the victim
    3. By standing on a dry surface and jerking the victim quickly away from the electrical source
    4. By running at the victim and knocking him or her clear with your body weight

Written Test

______c. Which of the following tools should be used to turn off electricity at the scene of an electrical emergency?

1. Alligator clip
2. Voltmeter
3. Wood-handled axe or insulated cutters
4. Ground-fault circuit-interrupter

______d. Why should the rescuer at an electrical emergency call for assistance?

1. It takes two people to remove a victim from electrical contact.
2. One person must perform surveillance on the power source to ensure that it is not reactivated.
3. One person can call for medical assistance while the other provides first aid
4. It takes two people to perform the complex first aid measures necessary

______e. What should the rescuer do if the victim's pulse is detectable but breathing has stopped?

1. Administer mouth-to-mouth resuscitation
2. Administer CPR
3. Administer Heimlich maneuver
4. Administer lung thump

______f. What should the rescuer do if the victim's heartbeat has stopped?

1. Administer mouth-to-mouth resuscitation
2. Administer CPR
3. Administer Heimlich maneuver
4. Administer lung thump

______g. What is the first thing the rescuer should do when treating the victim's electrical burns?

1. Cover his or her own mouth and nose with clean handkerchief.
2. Locate and treat both the entrance and exit wounds.
3. Apply a cool, clean compress.
4. Cover the wound with a sterile, dry dressing

______h. In what position should the victim's feet be when being treated for traumatic shock?

1. Level with head
2. Slightly below head level
3. Slightly above head level
4. Knees bent, feet at head level

***Permission to duplicate this test is granted.**

Electrical Safety
Unit 3

Unit Evaluation Form

Student Name ______________________________ Unit Rating __________

Assignment Sheet 1—Identify and Describe Safety Violations Rating _____

Comments: ____

____

Assignment Sheet 2—Solve Problems Concerning Electrical Safety Practices Rating _____

Comments: ____

____

Written Test Scores

Pretest _____ Posttest _____ Other _____

Other ____

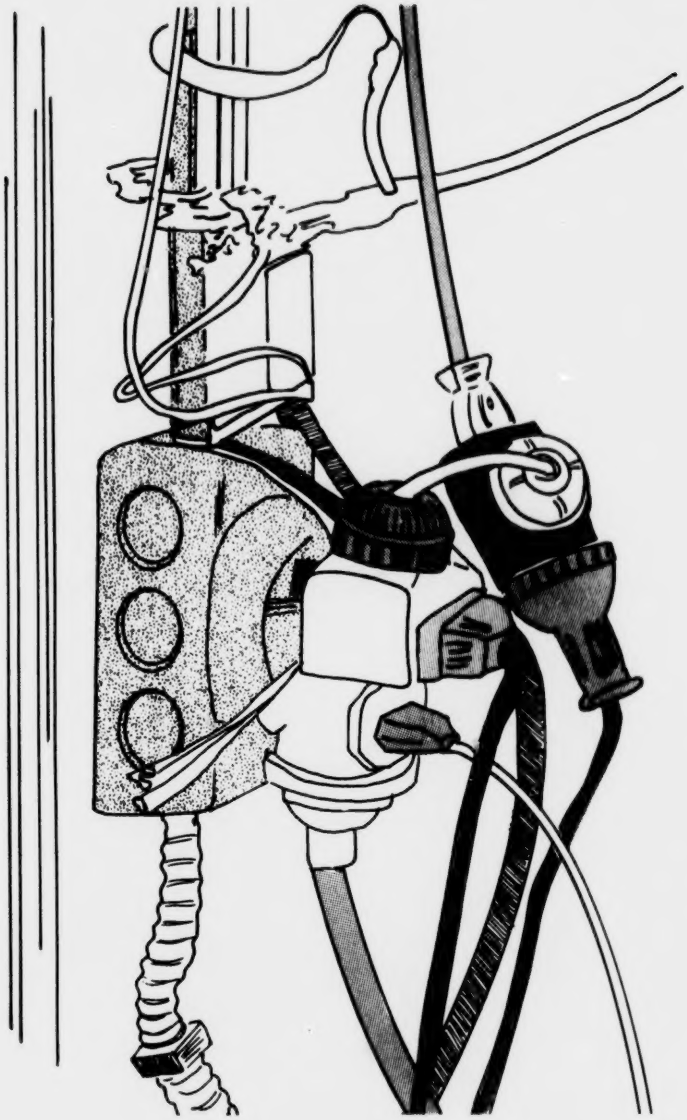
____

Teacher Signature ______________________________ Date __________

Student Signature ______________________________ Date __________

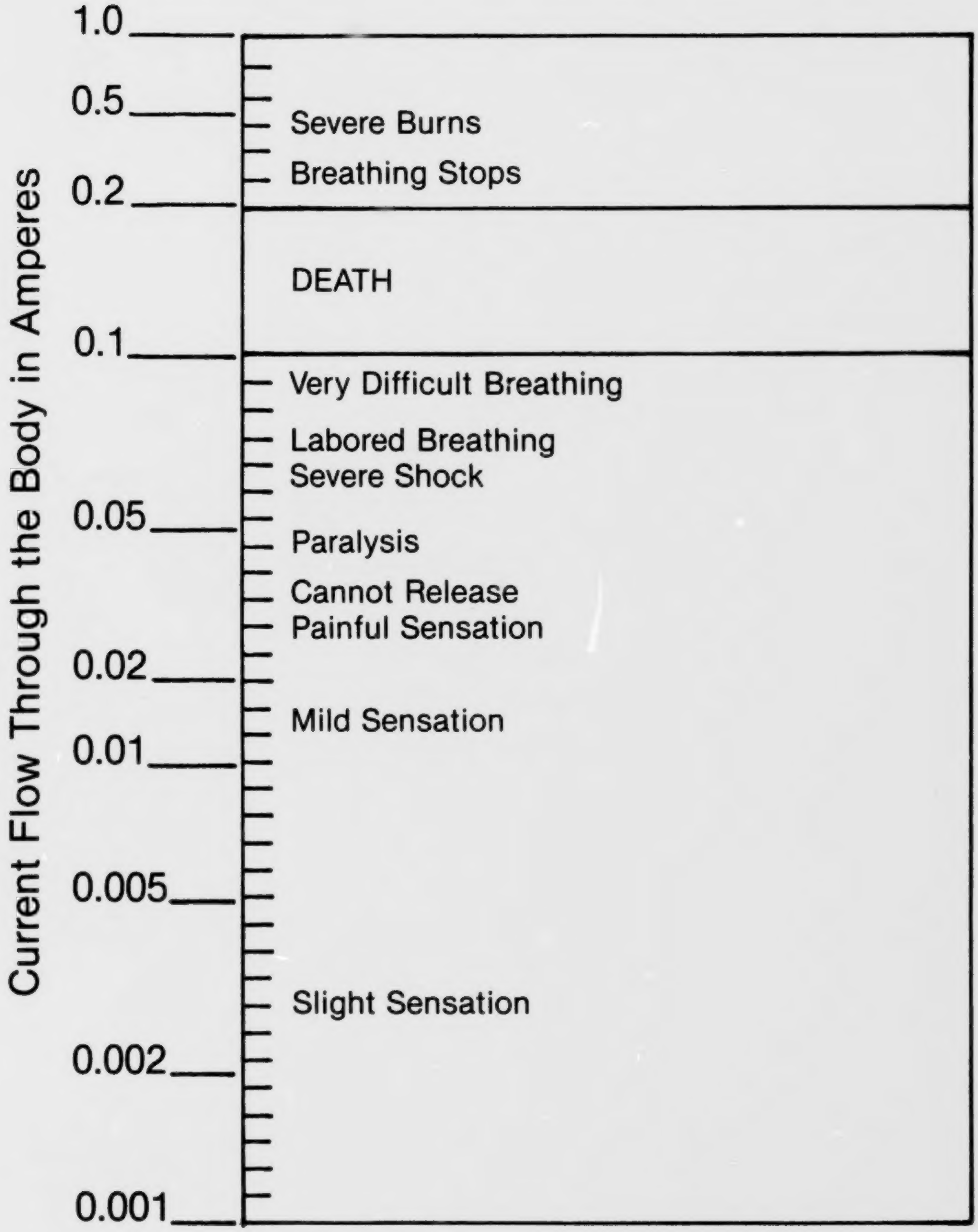
***Permission to duplicate this form is granted.**

Fire Prevention

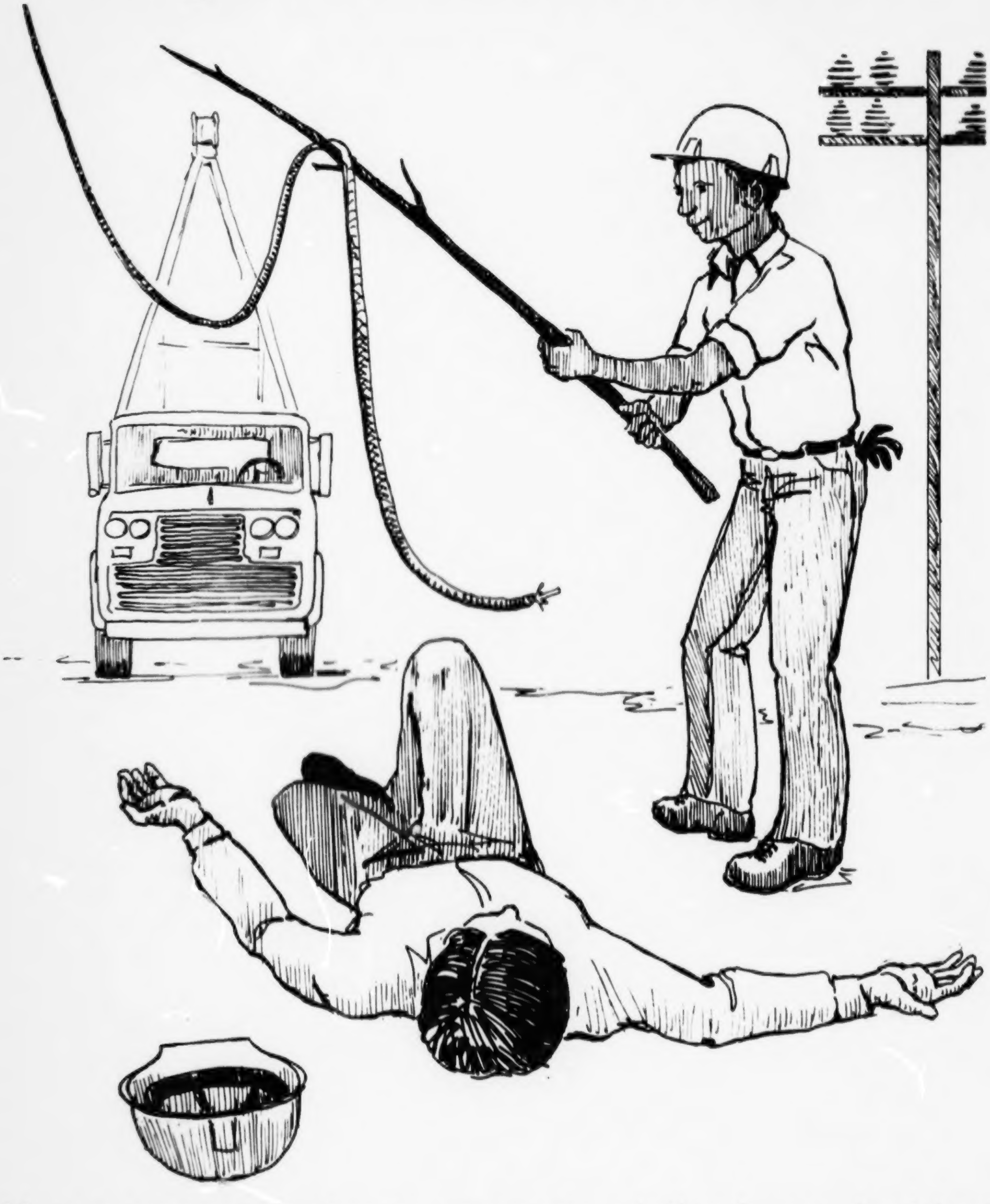


Improper use of electrical equipment
is dangerous.

Electric Shock Versus Body Sensation



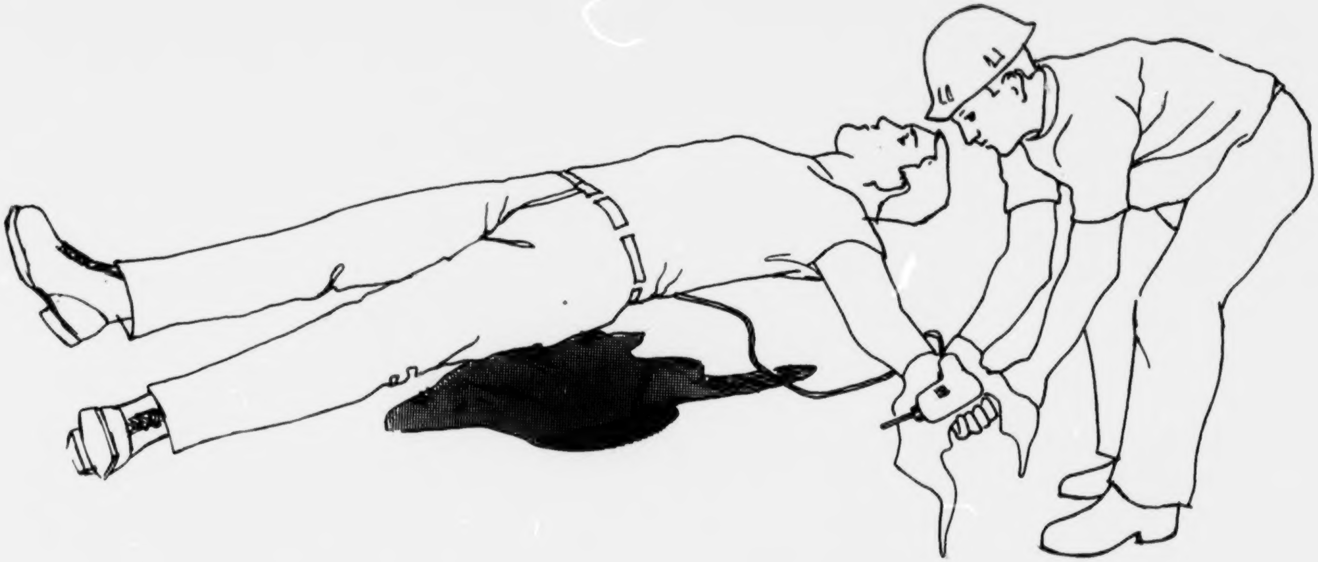
Dangers of Rescue Procedures



Use a nonconductor to separate victim from electrical circuit.

Do not touch the electrical circuit or the victim unless the power is off or you are insulated.

Dangers of Rescue Procedures
(Continued)



Do not attempt to move a victim
without some form of insulation
such as paper or cloth to protect yourself.

Electrical Safety
Unit 3

Information Sheet

1. **Terms and definitions**

    a. **Ampere**—Unit of measure for electrical current or intensity of electron flow

    b. **Conductor**—Material through which electrons flow easily

    Example: Any current-carrying device such as a wire or copper bar

    c. **Cube tap**—A device that plugs into a receptacle and provides space for connection of two or more attachment plugs

    d. **Current**—Electron flow through a conductor

    e. **Ground**—Electrical point on any good conductor that is connected to a common chassis with zero relative voltage; usually conductors are connected to the earth

    f. **Grounded**—Connected to earth or to some conducting body that serves in place of the earth

    g. **Ground-fault circuit-interrupter**—Breaker or device designed to protect individuals and equipment by deenergizing or tripping a circuit when current to ground reaches 0.0005 ampere

    h. **Hertz**—One complete positive or negative cycle in an alternating current circuit

    i. **Hydraulic**—A system by which equipment is powered by liquid

    j. **Multi-outlet assembly**—A type of surface or flush raceway designed to hold conductors and receptacles

    k. **Ohm**—Unit of measure for electrical resistance

    l. **Pneumatics**—A system by which equipment is powered by air

    m. **Volt**—Unit of measure for electrical pressure

2. **Major causes of electrical accidents**

    a. Rushed or distracted personnel (carelessness)

    b. Failure to verify that equipment was deenergized

    c. Misuse of tools or equipment

Information Sheet

3. **Basic electrical safety practices** (Figure 1)

   a. Never underestimate the danger of 110-volt AC circuits.

      Note: The small number of worldwide electrical accidents that prove fatal—about 1,000 per year over the past 15 years—is due to the general recognition that electricity is inherently dangerous. However, more people die from 110-volt electrical shock than from any other voltage. This statistic is mostly due to those individuals who make the false assumption that 110-volt current is not dangerous and does not pose a life-threatening hazard.

   b. Watch out for electrical arcs; they can cause bad burns.

   c. Do not operate equipment beyond its rated capacity.

   d. Never install equipment that will overload a circuit.

   e. Never bypass a fuse.

   f. Be sure that all current-carrying electrical lines are well insulated.

   g. Always check a circuit for voltage before servicing.

   h. Know where all emergency shutdown switches are located.

   i. Work on live (energized) circuits only when absolute necessary.

   j. Look for burned wires on electrical devices.

   k. Never touch a conductor without first testing.

   l. Look for loose conductors in electrical systems.

   m. Do not make any adjustment or repairs to any electrical equipment until all power has been disconnected or the electrical breaker has been turned off.

      Note: Adjustments or repairs should be performed only by authorized persons.

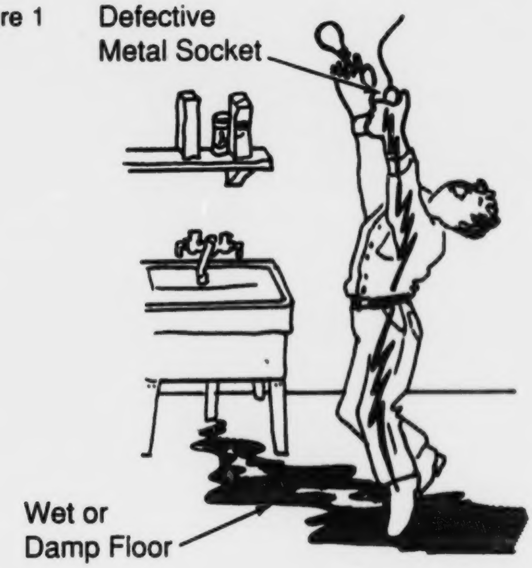
   n. Properly ground all electrical equipment and tools to prevent injury to the operator.

Information Sheet

o. Do not operate electrical parts while wearing wet gloves or wet clothing.

Note: To prevent harmful body shocks, keep hands, feet, and clothing dry, and use a dry board or rubber mat when water, moisture, or perspiration cannot be avoided.

Figure 1



p. Never work alone when working with more than 50 volts.

4. **Electrical fire prevention practices**

   a. Use extension cords only within their designated rating.

   b. Never let multi-outlet assemblies or cube taps cause overloads.

   c. Never use frayed or deteriorated extension cords.

   d. Never tamper with fuses to change their current-carrying capacity.

5. **Safety practices around live circuits**

   a. Use a reliable circuit tester or voltmeter to identify live circuits.

   b. Stand on a dry surface.

   c. Use only one hand when possible.

Information Sheet

   d. Never leave tools lying near conductors.

   e. Wear suitable insulated hand covering.

   f. Return all tools to your pouch when through with them.

6. **Proper grounding**

   a. Always check electrical equipment for proper grounding before working on it.

   b. Proper grounding allows the fault current to clear the overcurrent device, thus providing safe operation.

   c. Properly grounded equipment provides a pathway for stray current that may otherwise go through the operator's body.

   d. Loose wires that touch a case or housing in electrical equipment can cause electrical shock to anyone who touches the equipment if it has not been properly grounded.

   e. Loose connections can be detected by heated or discolored conductors, a burning odor, or carbon tracking.

7. **Importance of third wire**

   Note: To avoid electrical shock, always check for a third wire (ground wire) before using electrical equipment.

   a. It is installed for personal protection.

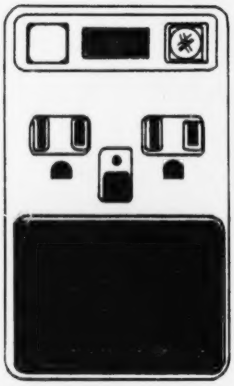
   b. It provides an alternate path for current in case of a short.

   c. It can save a person's life.

Information Sheet

8. **Ground-fault circuit-interrupters (GFCI)** (Figure 2)

Figure 2



a. Are personal safety devices designed to protect individuals or equipment by deenergizing or tripping a circuit when current to ground reaches 0.0005 ampere

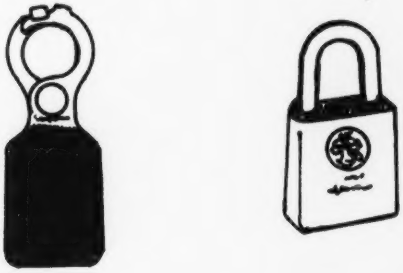
b. Are required on 15- and 20-ampere receptacle outlets used for temporary power supply at construction sites

   Note: See Unit 14, "Overcurrent Protection," Objective 8, for a list of installations that require ground-fault circuit-interrupters.

c. Interrupt flow of current in substantially less time than a normal overcurrent device will

9. **When to use lockout devices** (Figure 3)

Examples: Figure 3



a. Use when more than one power source is present.

b. Always use when hydraulic position could change.

c. Always use when pneumatic position could change.

d. Use to lock off all electrical devices before working on equipment.

10. Facts about electrical shock

a. High voltage (low current) tends to knock the victim away from the circuit, minimizing exposure time.

b. High current tends to cause the body to adhere to the circuit, so that the victim cannot let go.

- At about 1 milliampere (0.0010 ampere), a slight shock will be felt.
- At about 10 milliamperes (0.0010 ampere), the shock is severe enough to paralyze muscles, but a person may be able to let go of the conductor.
- At about 100 milliamperes (0.1 ampere) the shock is usually fatal if it lasts 1 second or more.

Note: Human body resistance varies from about 500,000 ohms when dry to about 300 ohms when wet. Because of this, voltages as low as 30 volts can cause enough current to be fatal. Any circuit with a potential of at least 30 volts must be considered dangerous.

11. Treating the victim of electrical shock

a. Safely remove victim from contact with the source of electricity using the following procedure:

Caution: Do not touch the electrical circuit or the victim unless the power is off or you are insulated.

- Turn off the electricity, using a switch or circuit breaker, or cut cables or wires with a wood-handled axe or insulated cutters.

Caution: Be aware that throwing the circuit breaker on systems with auxiliary or backup power only momentarily deenergizes the system.

Note: Rescue must be effected quickly. After five minutes, the chances of saving the individual greatly decrease.

Information Sheet

- As an extra precaution, and only after the electricity has been turned off, use a stick, rope, leather belt, coat, blanket, or any other dry, nonconductor of electricity to separate the victim from the electrical circuit.

  Caution: Do not take hold of the victim with your bare hand.

b. Call for assistance.

- Others in the area may be more knowledgeable than you about treating the victim.
- Another person can call for professional medical help while you administer first aid.

c. Check the victim's breathing and heartbeat.

Note: Time is life at this point!

- If a pulse is detectable but breathing has stopped, administer mouth-to-mouth resuscitation until the victim resumes breathing or medical help arrives.
- If the heartbeat has stopped, administer cardiopulmonary resuscitation (CPR), until the victim's heartbeat resumes or medical help arrives—but only if you have trained in the proper technique.

  Caution: CPR can sometimes cause more harm than good to a victim unless the person administering the first aid has been trained in the proper procedure.

- If both the heartbeat and breathing have stopped, alternate between cardiopulmonary resuscitation and mouth-to-mouth resuscitation, but again, only if you have been trained in this technique.

d. Administer first aid for burns.

- Cover your mouth and nose with a clean handkerchief to prevent breathing germs on the victim.
- Locate and treat both the entrance and exit burns.
- Cool burns with a damp compress and then cover with a dry, sterile dressing.

  Caution: Do not attempt any other treatment of burns.

Information Sheet

e. Administer first aid for traumatic shock.

- Lay victim down.
- Elevate victim's legs slightly above head level.
- Cover to prevent loss of body heat.

f. Continue treatment, but only within your ability, until medical help arrives.

Electrical Safety
Unit 3

Assignment Sheet 1—Identify and Describe Safety Violations

Name ______________________________ Overall Rating __________

Evaluation criteria	Rating
Inspected all listed items	______
Accurately described all safety violations	______

Directions: Complete the following electrical safety checklist for your school shop area. After you have inspected all of the items described, describe the safety violations for those you have checked in the "No" column.

Place a (✓) in the appropriate box.

		Yes	No
A.	Cords on all machines are properly connected.	☐	☐
B.	Extension cords are used within designated rating.	☐	☐
C.	Extension cords are in good working condition.	☐	☐
D.	Shop area is properly wired.	☐	☐
E.	All electrical hand tools are properly grounded.	☐	☐
F.	All electrical equipment is properly grounded.	☐	☐
G.	Ground fault interrupters are present and in working order.	☐	☐
H.	All machines are marked with safety operations.	☐	☐
I.	Shop safety rules are posted.	☐	☐
J.	Safety lanes are marked using proper color designations.	☐	☐
K.	Exits from shop area are properly marked.	☐	☐
L.	Fire extinguishers are properly charged.	☐	☐

Assignment Sheet 1

		Yes	No
M.	Fire extinguishers are easily accessible.	☐	☐
N.	Areas around electrical equipment are clean and dry.	☐	☐
O.	Areas around water fountains are clean and dry.	☐	☐
P.	First aid kit is properly stocked and marked for identification.	☐	☐
Q.	Emergency numbers are posted at phone.	☐	☐
R.	General housekeeping practices are observed.	☐	☐

Safety Violations

Electrical Safety
Unit 3

Assignment Sheet 2—Solve Problems Concerning Electrical Safety Practices

Name ______________________ Overall Rating __________

Evaluation criteria	**Rating**
Accurately interpreted circumstances	_____
Took realistic and safe course of action	_____

Directions: Read the following brief problems concerning electrical safety practices. Describe the appropriate safe course of action to take.

A. You are working on a project in the school shop and the person next to you shorts out his project and it catches fire. What are the safety procedures you should take?

B. While working at the project house, you hear a shout and turn to see that a fellow worker has fallen to the floor with an electric line under his body. What is the very first thing you should do?

C. You are called out on a job after a storm to repair an electric pump in a basement which is flooded with water. List the things you should do before repairing the pump.

Hand Tools
Unit 4

Objective Sheet

Unit Objective

After completing this unit, the student should be able to identify, use, and care for common hand tools used in the electrical field. The student should demonstrate these competencies by completing the job sheets and scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to hand tools with their correct definitions.
2. Label common hand tools used in the electrical field.
3. Label electricity-specific hand tools used in the electrical field.
4. Match common hand tools with their uses.
5. Match electricity-specific hand tools with their uses.
6. List factors to consider when purchasing hand tools.
7. Select true statements about rules for care of various hand tools.
8. Measure objects using a wood folding rule. (Assignment Sheet 1)
9. Clean and lubricate an adjustable hand tool. (Job Sheet 1)
10. Use a cutting/crimping tool. (Job Sheet 2)
11. Adjust wire strippers. (Job Sheet 3)
12. Set up and use a hacksaw to cut conduit. (Job Sheet 4)
13. Ream rigid conduit. (Job Sheet 5)
14. Bend EMT conduit. (Job Sheet 6)
15. Use a knockout punch. (Job Sheet 7)
16. Use a hole saw. (Job Sheet 8)

Hand Tools
Unit 4

Suggested Activities

Instructional Plan

Preparation

1. Read the unit carefully and plan for instruction. Study the specific objectives to determine the order in which you will present them.
2. Review Teaching Suggestions section that follows. Plan for classroom activities.
3. Plan your presentation to take advantage of student learning styles and to accommodate special needs students.
4. Make transparencies from the transparency masters included with this unit. These appear in the teacher edition only and are designed to be used with the following objectives:

   TM 1—Using a Channel-Lock Wrench (Objective 2)
   TM 2—Using a Circuit Tester (Objective 3)

5. Develop teaching plan. Adjust for different learning styles.
6. Make copies of Unit Evaluation Form.

Delivery and Application

7. Provide students with unit of instruction.
8. Discuss unit and specific objectives.
9. Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
10. Discuss assignment sheet and schedule due dates. Review criteria for evaluation.
11. Discuss and demonstrate the job sheets. Review the evaluation criteria for each. Schedule performance dates.

Suggested Activities

Evaluation

12. Discuss the use of the Unit Evaluation Form with students. Discuss the rating scale that will be used for student evaluation.

13. Make copies of the written test. Add or modify test items as needed.

14. Give written test.

15. Compile assignment sheet and job sheet ratings and written test scores on the Unit Evaluation Form. Include any additional assignments.

16. Reteach and retest as required.

17. Meet individually with students to evaluate their progress throughout this unit of instruction, and indicate to them possible areas of improvement.

Teaching Suggestions

Note: Skill areas appearing in boldface type in the Teaching Suggestions refer to the academic and workplace skills identified by the American Society for Training and Development (ASTD) and the U.S. Department of Labor. These have been adapted by MAVCC.

1. Invite local suppliers to show various tools, and to discuss the advantages and disadvantages of each design. Have students take notes on the discussion. Skill areas: **Listening, writing**

2. Visit local tool suppliers. Have students compare and contrast quality and purposes of tools available to the electrician. Skill area: **Critical thinking**

3. Demonstrate the proper use and care of basic hand tools. Allow students to return your demonstrations. Skill area: **Learning to learn**

4. Have students practice their measuring skills by assigning them various conduit and areas around the classroom and shop to be measured with a folding rule. Skill area: **Math**

5. Supplement hand tools as you deem necessary.

Suggested Activities

Resources Used in Developing This Unit

1. Crost, Terrell, ed. *American Electrician's Handbook*, 11th ed. New York: McGraw-Hill, 1987.

2. *Greenlee Tool Catalog*. Rockford, IL: Greenlee Textron, Inc., 1992. Phone 1-800-435-0786.

3. *Klein Tools Catalog*. Klein Tools, Inc., 7200 McCormick Blvd., Chicago, IL 60645. Phone: (312) 677-9500.

4. Siebert, Leo N. *Introduction to Industrial Electricity-Electronics*. Stillwater, OK: Oklahoma Curriculum and Instructional Materials Center.

5. Taylor, Mark. *Residential Wiring*. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1983.

Instructions for Evaluating Student Performance

Assignment Sheets—Be sure the student understands the criteria on which the evaluation is based. Assign a point value to each criterion and convert the total points to a percentage for grading.

Job Sheets—Be sure the student understands the criteria on which the evaluation is based. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in either the teacher edition or student manual. Then observe the student performing the procedure. Rate both process and product.

> Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily achieved the step(s) for each checkpoint area. If the student is unable to correctly complete the procedure, have the student review the materials and try again.
>
> Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria which have been provided as part of the job sheet. Complete the rating by assigning a point value to each criterion and by converting the point total to a percentage for grading. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Suggested Activities

Sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) which best fits your program needs.

Option A

4 - Skilled—Can perform job with no additional training.
3 - Moderately skilled—Has performed job during training program; limited additional training may be required.
2 - Limited skill—Has performed job during training program; additional training is required to develop skill.
1 - Unskilled—Is familiar with process, but is unable to perform job.

Option B

Yes—Can perform job with no additional training.

No—Is unable to perform job satisfactorily.

Hand Tools
Unit 4

Answers to Assignment Sheet 1

A. 1. 3″
   2. 1″

B. 1. $3\frac{9}{16}$″
   2. $1\frac{3}{8}$″

C. 1. 1″
   2. $2\frac{1}{8}$″
   3. $1\frac{7}{16}$″

D. 1. $2\frac{3}{8}$″
   2. 1″
   3. $2\frac{1}{16}$″
   4. $1\frac{3}{16}$″

Hand Tools
Unit 4

Answers to Written Test

1.

a.	13	e.	3	i.	6	m.	7
b.	11	f.	15	j.	1	n.	5
c.	16	g.	4	k.	9	o.	2
d.	10	h.	8	l.	14	p.	12

2. a. Folding rule
   b. Hacksaw
   c. Drill motor
   d. File
   e. Hole saw and arbor
   f. Keyhole saw
   g. Channel-lock wrench
   h. Ship auger drill bit
   i. Tap tool
   j. Drill brace
   k. Screw-holding screwdriver
   l. Slip-joint pliers
   m. Phillips screwdriver
   n. Drill bit
   o. Flat-blade screwdriver
   p. Reciprocating saw
   q. Hex key set (Allen wrenches)
   r. Ball peen hammer
   s. Bolt cutter
   t. Magnetic torpedo level
   u. Knockout punch
   v. Chisel
   w. Center punch

3. a. Soldering iron (approximately 25 W)
   b. Lineman's pliers
   c. Pulling grip-sleeve
   d. Safety glasses
   e. Electrician's knife
   f. Diagonal pliers
   g. Torque screwdriver
   h. Needle-nose pliers
   i. Rubber hose
   j. Pipe reamer
   k. Tool pouch
   l. Circuit tester
   m. Torque wrenches

Answers to Written Test

n. Cutting/crimping tool
o. Electrician's hammer
p. Adjustable wire strippers
q. Drop chain
r. Nut driver
s. Combination conduit/EMT bender
t. Cable cutter
u. Steel fish tape and reel
v. Hickey bender
w. Heat gun
x. Conduit reamer
y. Cable bender
z. Fuse puller
aa. Soldering gun (250 W)
bb. Rubber blanket
cc. Rubber gloves

4. a. 19
b. 10
c. 14
d. 2
e. 4
f. 6
g. 18
h. 20
i. 16
j. 11
k. 13
l. 1
m. 3
n. 7
o. 12
p. 15
q. 17
r. 9
s. 5
t. 8

5. a. 29
b. 2
c. 9
d. 10
e. 27
f. 23
g. 13
h. 5
i. 14
j. 1
k. 15
l. 20
m. 16
n. 17
o. 18
p. 19
q. 21
r. 22
s. 3
t. 24
u. 6
v. 25
w. 11
x. 4
y. 7
z. 26
aa. 8
bb. 28
cc. 12

6. a. Size
b. Design
c. Quality

7. a, b, c

Hand Tools
Unit 4

Written Test

Name ______________________ Score ______________

1. Match terms related to hand tools with their correct definitions. Write the correct numbers in the blanks.

______a. Industrial blueprint; industrial wiring diagram

______b. Circuit with voltage applied

______c. Metal connector crimped or soldered to a conductor; allows conductor to be fastened with a screw or bolt

______d. Nonconductive material that prevents leakage of electricity from a conductor and protects against accidental contact

______e. Device for holding a tool component rigid

______f. Nonconductive material placed around a conductor for insulation; does not shrink

______g. Box where electrical connections are made, usually through circuit breakers

______h. Safety device placed in a circuit; in cases of excessive current, it melts, thus opening the circuit

______i. Pipe or tube that holds and protects wires or cables

______j. Shaft or spindle used to hold a revolving cutting tool or the work to be cut

______k. Nonconductive material placed around a conductor for insulation; shrinks when heated

1. Arbor
2. Cable-tie
3. Chuck
4. Circuit box
5. Conductor
6. Conduit
7. Coupling
8. Fuse
9. Heat shrink
10. Insulation
11. Live circuit
12. Plasterboard
13. Print
14. Snap ring
15. Spaghetti
16. Wire lug

Written Test

______l. Metal ring that fastens around or in a shaft to keep other parts stationary

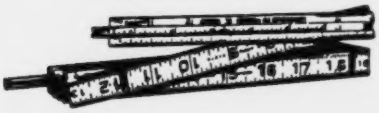
______m. Mechanical device for connecting conduit and cabling

______n. Material through which electrons flow easily; used to connect components

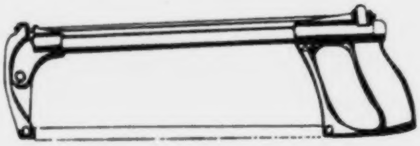
______o. Plastic straps with pull-through fasteners for binding together conductors or cables

______p. Thin board formed of layers of plaster and paper; Sheetrock

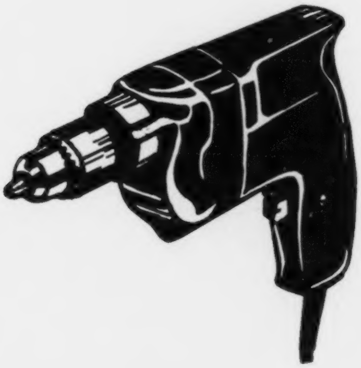
2. Label the following common hand tools used in the electrical field. Write the correct names in the spaces provided.



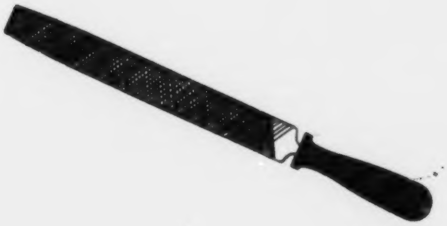
a. ______________________



b. ______________________



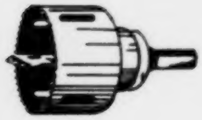
c. ______________________

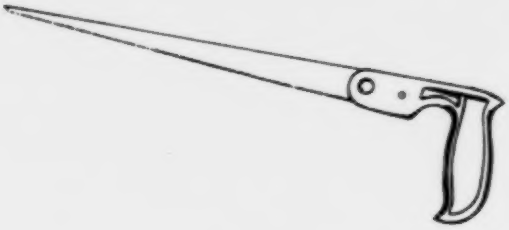


d. ______________________

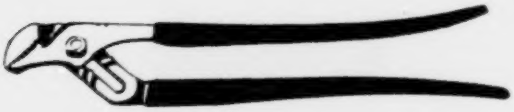
237

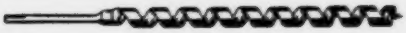
Written Test



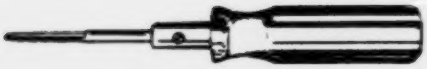


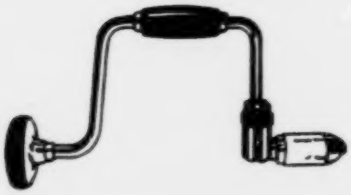
e. ______________________________ f. ______________________________





g. ______________________________ h. ______________________________





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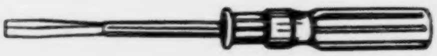
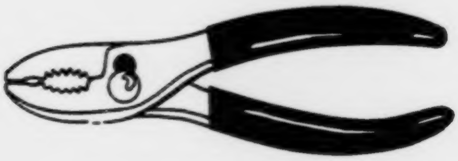
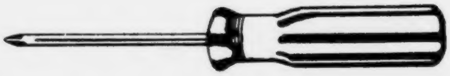
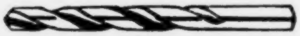




k. ______________________________ l. ______________________________

Written Test





m. ____________________

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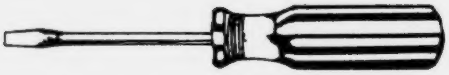
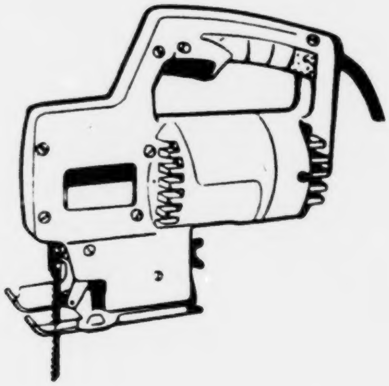
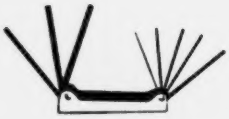
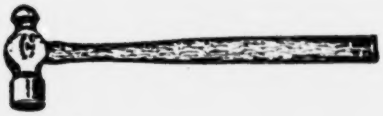




o. ____________________

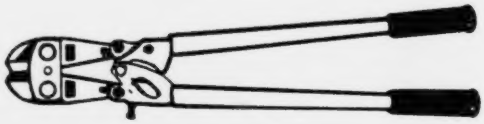
p. ____________________

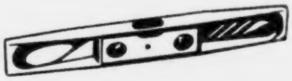




q. ____________________

r. ____________________

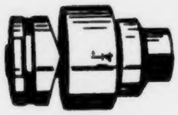


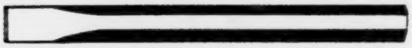


s. ____________________

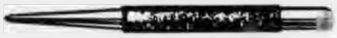
t. ____________________

Written Test



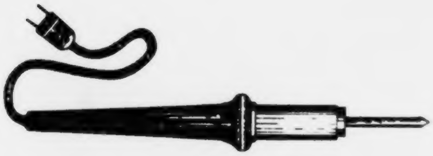


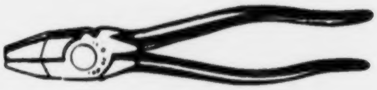
u. ______________________________ v. ______________________________



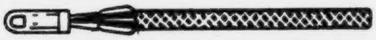
w. ______________________________

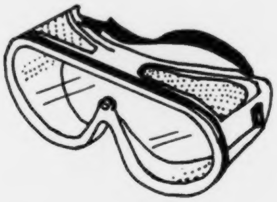
3. Label the following electricity-specific hand tools used in the electrical field. Write the correct names in the spaces provided.



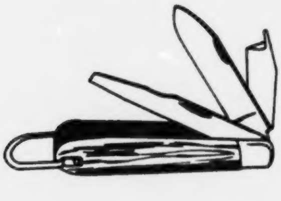


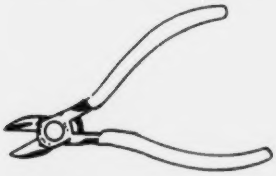
a. ______________________________ b. ______________________________





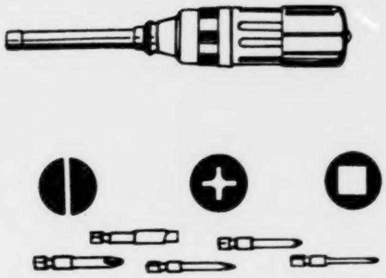
c. ______________________________ d. ______________________________





e. ______________________________ f. ______________________________

Written Test



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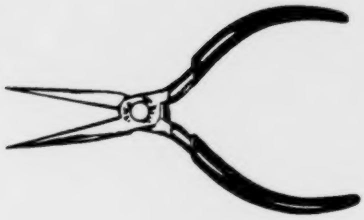
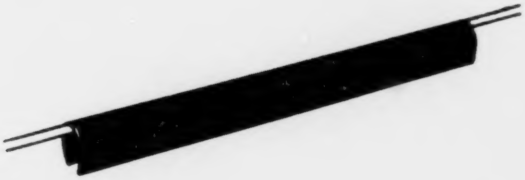
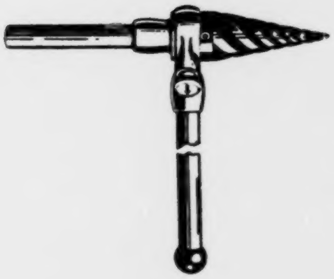


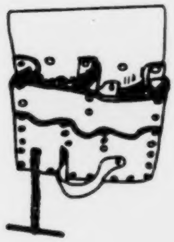
h. ____________________



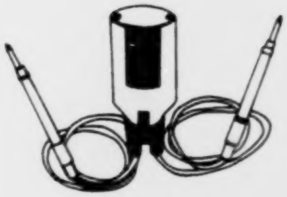
i. ____________________



j. ____________________

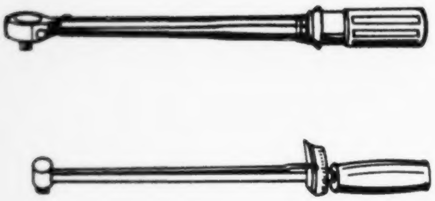


k. ____________________

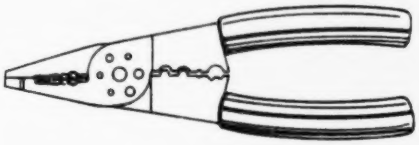


l. ____________________

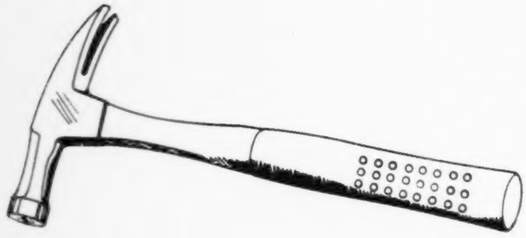
Written Test



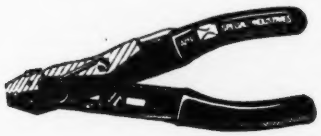
m. ____________________



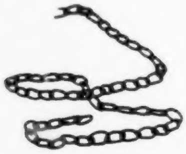
n. ____________________



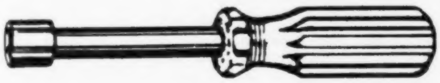
o. ____________________



p. ____________________

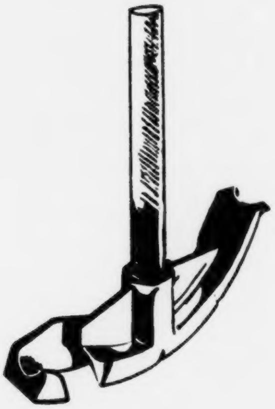


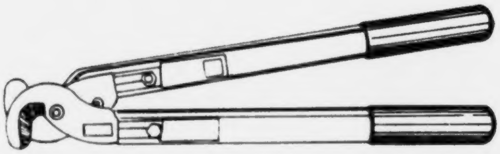
q. ____________________



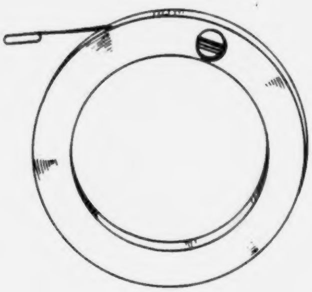
r. ____________________

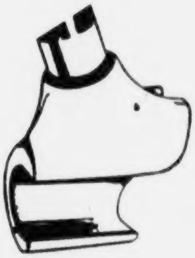
Written Test



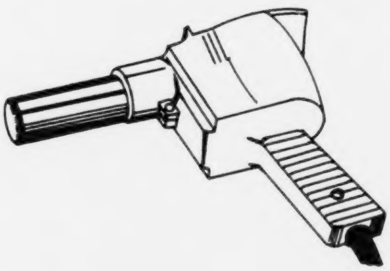


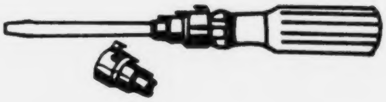
s. ______________________ t. ______________________





u. ______________________ v. ______________________

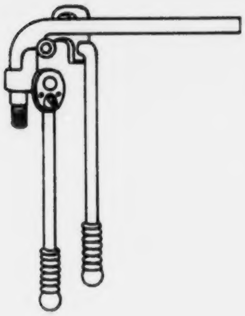




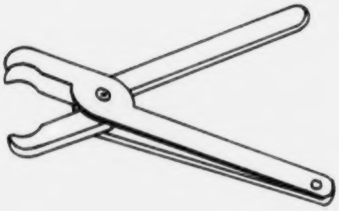
w. ______________________ x. ______________________

243

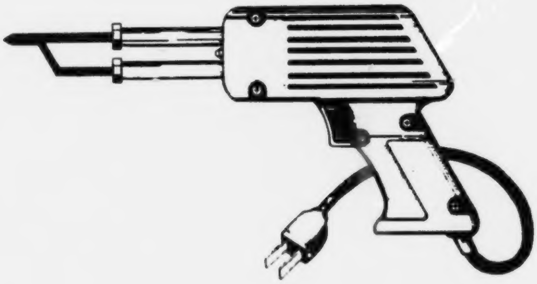
Written Test



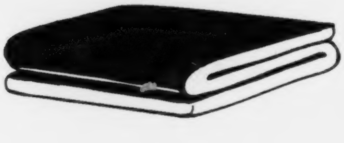
y. ______________________________



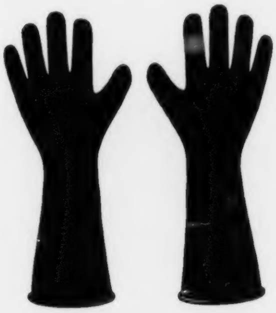
z. ______________________________



aa. ______________________________



bb. ______________________________



cc. ______________________________

244

Written Test

4. Match common hand tools with their uses. Write the correct numbers in the blanks.

______a. Cutting holes in plasterboard; needs electric power

______b. Making center tap for drilling

______c. Cutting large holes in metal boxes without drilling

______d. Installing and removing slot-head screws

______e. Holding and tightening couplings and conductors; holding, tightening, and turning conduit

______f. Cutting large conductor or cables, conduit, and metal for electronic cabinets

______g. Drilling holes for electronic cabinets; needs electric power

______h. Holding screw for use in limited-space installation

______i. Boring holes for conduit cable

______j. Cutting large bolts, chains, locks, and so forth

______k. Leveling conduit and equipment

______l. Measuring distances on prints, conduit, cable, and so forth

______m. Installing and removing Phillips-head screws

______n. Cutting holes in plasterboard for circuit boxes; needs no electric power

______o. Installing and removing Allen screws

1. Folding rule or tape measure
2. Flat-blade screwdriver
3. Phillips screwdriver
4. Slip-joint pliers
5. Channel-lock wrench
6. Hacksaw
7. Keyhole saw
8. File
9. Chisel
10. Center punch
11. Bolt cutter
12. Hex key set (Allen wrenches)
13. Magnetic torpedo level
14. Knockout punch
15. Hole saw
16. Drill brace and drill
17. Tap tool
18. Drill motor and drill

Written Test

______p. Cutting large holes in metal

______q. Retapping damaged threads, equipping drill holes with bolt threads, determining bolt size

______r. Notching wood for boxes or cables

______s. Gripping and turning work; versatile

______t. Deburring large conduit and holes in circuit boxes, sharpening tools, cleaning soldering gun tips and soldering iron

19. Reciprocating saw
20. Screw-holding screwdriver

5. Match electricity-specific hand tools with their uses. Write the correct numbers in the blanks.

______a. Insulating and protecting technician from electrial current

______b. Cutting small conductors, cutting conductors in limited spaces

______c. Checking circuits for power, checking fuses and breakers

______d. Reaming burrs from cut conduits and EMT

______e. Tightening Allenhead and bolt-type lugs to manufacturer's specifications

______f. Bending heavy conduit

______g. Removing fuses safely from equipment and circuit panels

______h. Cutting small conductors and bolts, stripping insulation from conductors, crimping wire lugs

______i. Protecting eyes from foreign objects and liquids

1. Needle-nose pliers
2. Diagonal pliers (dykes)
3. Lineman's pliers
4. Adjustable wire stripper
5. Cutting/crimping tool
6. Soldering iron
7. Soldering gun
8. Tool pouch
9. Circuit tester
10. Conduit reamer
11. Nut driver
12. Cable bender
13. Fuse puller

Written Test

______j. Cutting small conductors, forming loops on small conductors, holding conductors while soldering, stripping insulation from conductors when equipped with #12 stripper

______k. Driving and pulling nails, opening wooden crates, breaking plasterboard

______l. Pulling in conduit, tray, or overhead lines

______m. Cutting large copper or aluminum cables

______n. Drying electronic components and conductors, heat shrinking

______o. Pulling cables through wall

______p. Pulling conductors through conduit, pulling cables through insulated walls

______q. Deburring conduit

______r. Bending conduit for conductor installation

______s. Cutting large conductors, forming loops on large conductors, pulling and holding large conductors

______t. Opening paper cartons, stripping large conductors, stripping cables, tightening and loosening small screws when screwdriver not available

______u. Soldering small heat-sensitive components, soldering printed circuit boards

______v. Protecting wearer against electrical shock when working around energized equipment

14. Safety glasses and goggles
15. Electrician's hammer
16. Cable cutter
17. Heat gun
18. Drop chain
19. Steel fish tape and reel
20. Pulling grip-sleeve
21. Pipe reamer
22. Conduit bender
23. Hickey bender
24. Electrician's knife
25. Rubber gloves
26. Torque screwdriver
27. Torque wrench
28. Rubber hose (protective sleeve)
29. Rubber blanket

Written Test

______w. Installing and removing nuts and bolts, tightening and loosening nuts and long bolts

______x. Cutting small conductors, stripping insulation from conductors

______y. Soldering large conductors, splicing cables

______z. Tightening slotted lugs and screws to manufacturer's torque specifications

______aa. Holding and organizing tools

______bb. Insulating and protecting technician from high-power, uninsulated overhead lines

______cc. Assisting in bending large cables

6. List three factors to consider when purchasing hand tools.

a. ______________________________

b. ______________________________

c. ______________________________

7. Select true statements concerning rules for care of various hand tools. Write an "X" in the blanks before each true statement.

______a. Discard worn or damaged flat-blade screwdrivers.

______b. Keep pliers clean and free of rust.

______c. Do not lubricate worm gears on adjustable wrenches.

______d. Leave cutting edges exposed on cutting tools.

______e. Discard electrically powered tools with damaged cords.

______f. Unplug electrically powered tools by pulling cord.

***Permission to duplicate this test is granted.**

Hand Tools
Unit 4

Unit Evaluation Form

Student Name ______________________________ Unit Rating __________

Assignment Sheet 1—Measure Objects Using a Wood Folding Rule Rating _____

Comments: ____

____

Job Sheet 1—Clean and Lubricate an Adjustable Hand Tool Rating _____

Comments: ____

____

Job Sheet 2—Use a Cutting/Crimping Tool Rating _____

Comments: ____

____

Job Sheet 3—Adjust Wire Strippers Rating _____

Comments: ____

____

Job Sheet 4—Set Up and Use a Hacksaw to Cut Conduit Rating _____

Comments: ____

____

Job Sheet 5—Ream Rigid Conduit Rating _____

Comments: ____

____

Job Sheet 6—Bend EMT Conduit Rating _____

Comments: ____

____

Job Sheet 7—Use a Knockout Punch Rating _____

Comments: ____

____

Unit Evaluation Form

Job Sheet 8—Use a Hole Saw Rating ______

Comments: ____

____

Written Test Scores

Pretest ______ Posttest ______ Other ______

Other ____

____

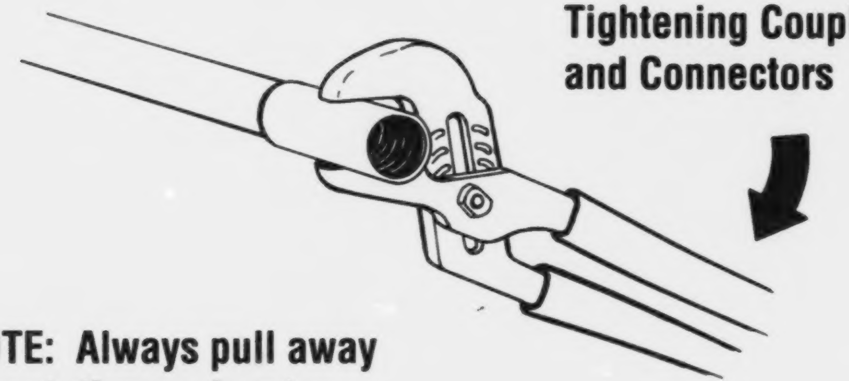
Teacher Signature ______________________ Date __________

Student Signature ______________________ Date __________

***Permission to duplicate this form is granted.**

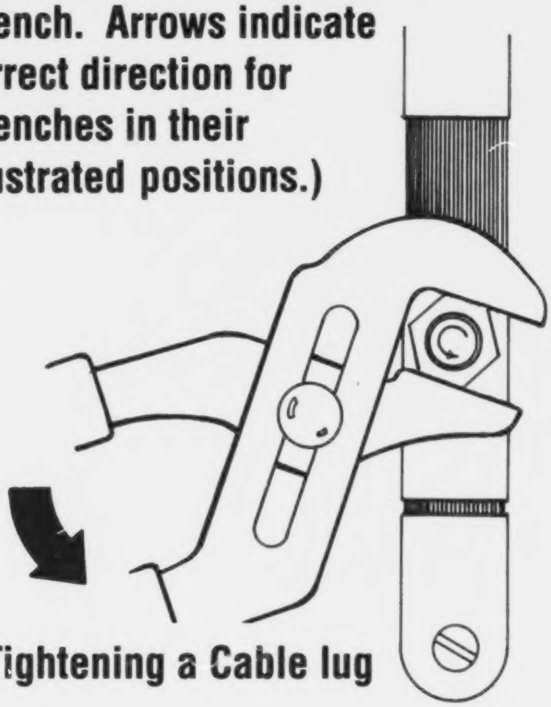
250

Using a Channel-Lock Wrench



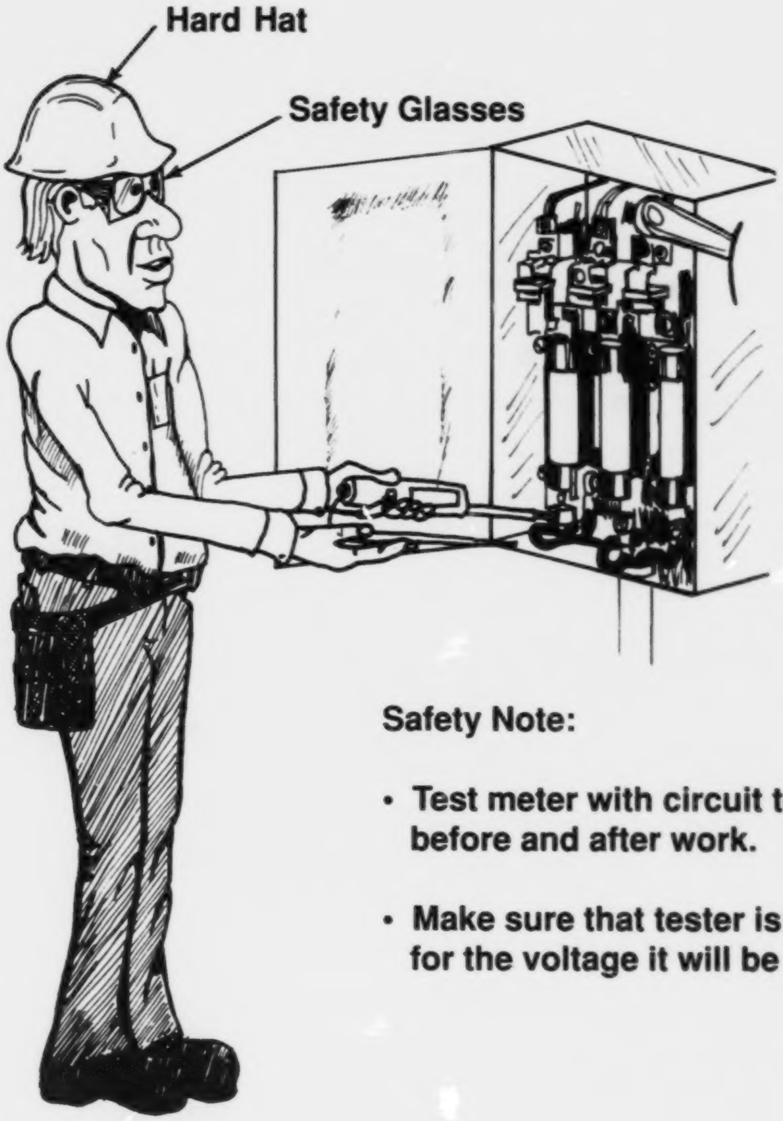
Tightening Couplings and Connectors

(NOTE: Always pull away from stationary jaw to avoid breaking or damaging wrench. Arrows indicate correct direction for wrenches in their illustrated positions.)



Tightening a Cable lug

Using a Circuit Tester


Hard Hat
Safety Glasses

Safety Note:

- **Test meter with circuit tester before and after work.**
- **Make sure that tester is rated for the voltage it will be used on.**

Hand Tools
Unit 4

Information Sheet

1. **Terms and definitions**

   a. **Arbor** — Shaft or spindle used to hold a revolving cutting tool or the work to be cut

   b. **Cable-tie** — Plastic straps with pull-through fasteners for binding together conductors or cables

   c. **Chuck** — Device for holding a component of a tool rigid

   d. **Circuit box** — Box where electrical connections are made, usually through circuit breakers

   e. **Conductor** — Material through which electrons flow easily; used to connect components

   f. **Conduit** — Pipe or tube that holds and protects wires or cables

   g. **Coupling** — Mechanical device for connecting conduit and cabling

   h. **Fuse** — Safety device placed in a circuit; in cases of excessive current, it melts, thus opening the circuit

   i. **Heat shrink** — Nonconductive material placed around a conductor for insulation; shrinks when heated

   j. **Insulation** — Nonconductive material that prevents leakage of electricity from a conductor and protects against accidental contact

   k. **Live circuit** — Circuit with voltage applied

   l. **Plasterboard** — Thin board formed of layers of plaster and paper; Sheetrock

   m. **Print** — Industrial blueprint; industrial wiring diagram

   n. **Snap ring** — Metal ring that fastens around or in a shaft to keep other parts stationary

   o. **Spaghetti** — Nonconductive material placed around a conductor for insulation; does not shrink

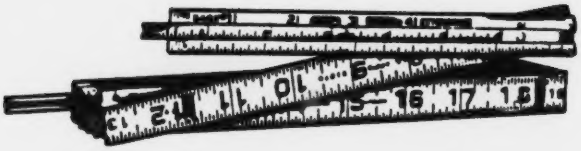
   p. **Wire lug** — Metal connector crimped or soldered to a conductor; allows conductor to be fastened with a screw or bolt

Information Sheet

2. **Common hand tools used in the electrical field** (Figures 1-23)

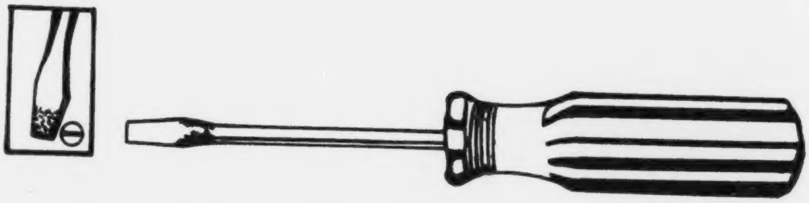
   a. Folding rule

   Figure 1



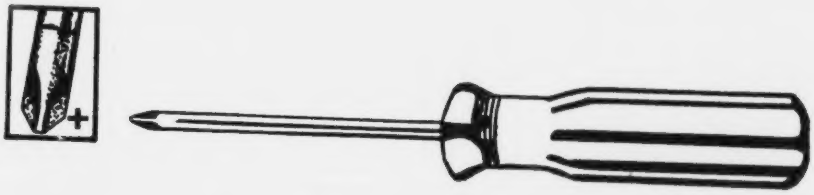
   b. Flat-blade screwdriver

   Figure 2



   c. Phillips screwdriver

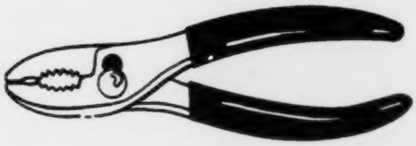
   Figure 3



Information Sheet

d. Slip-joint pliers

Figure 4

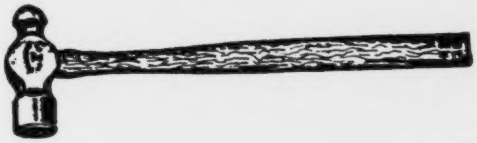


e. Channel-lock wrench

Figure 5

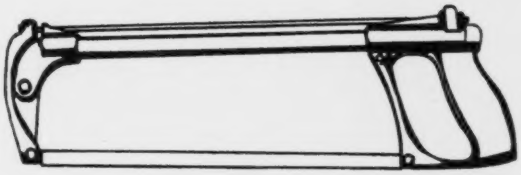
f. Ball peen hammer

Figure 6



g. Hacksaw

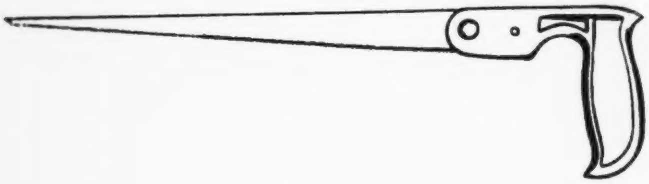
Figure 7



Information Sheet

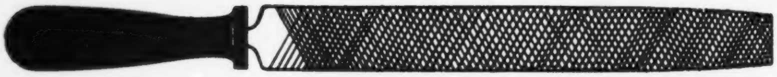
h. Keyhole saw

Figure 8



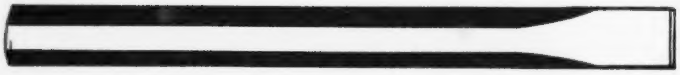
i. File

Figure 9



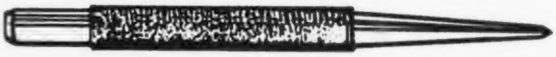
j. Chisel

Figure 10



k. Center punch

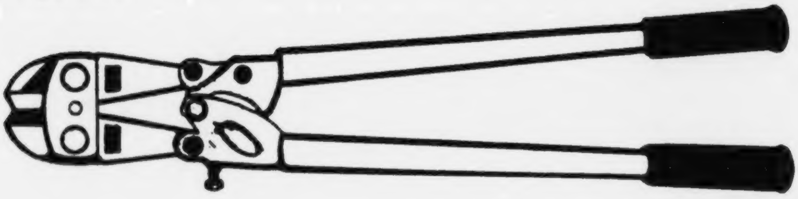
Figure 11



Information Sheet

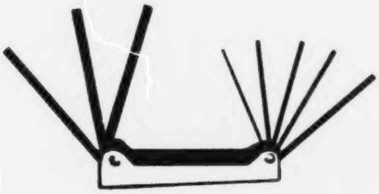
l. Bolt cutter

Figure 12



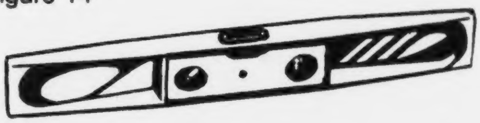
m. Hex key set (Allen wrenches)

Figure 13



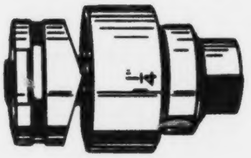
n. Magnetic torpedo level

Figure 14



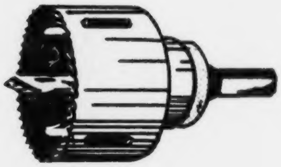
o. Knockout punch

Figure 15



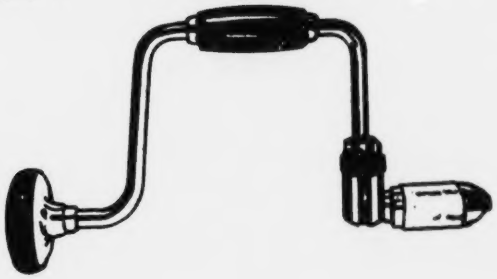
p. Hole saw and arbor

Figure 16



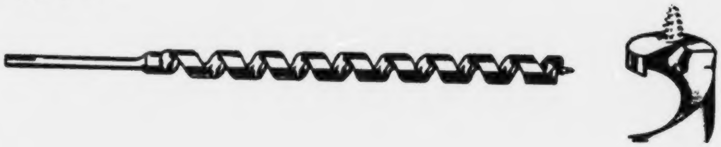
q. Drill brace

Figure 17



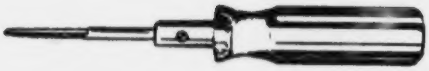
r. Ship auger drill bit

Figure 18



s. Tap tool

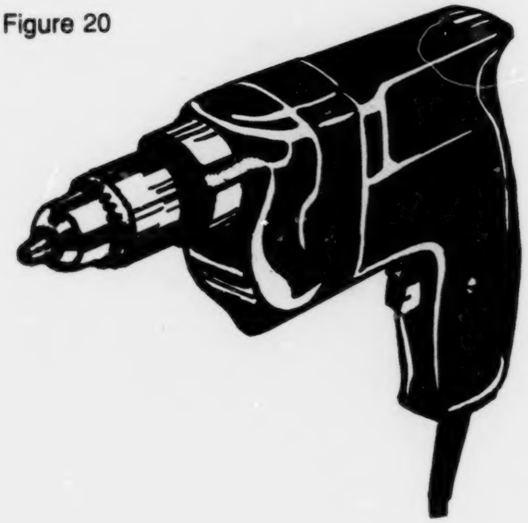
Figure 19



Information Sheet

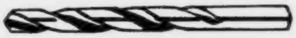
t. Drill motor

Figure 20



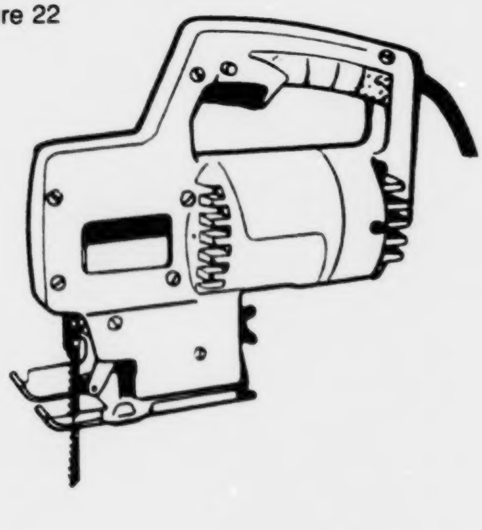
u. Drill bit

Figure 21



v. Reciprocating saw

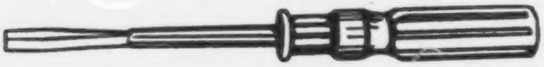
Figure 22



Information Sheet

w. Screw-holding screwdriver

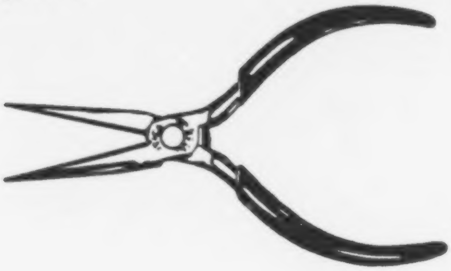
Figure 23



3. **Electricity-specific hand tools used in the electrical field** (Figures 24-53)

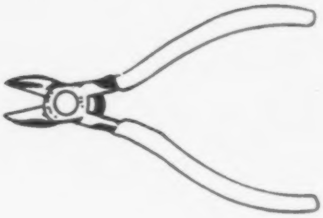
a. Needle-nose pliers

Figure 24



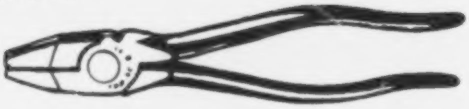
b. Diagonal pliers

Figure 25



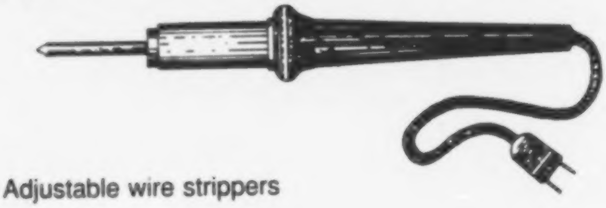
c. Lineman's pliers

Figure 26



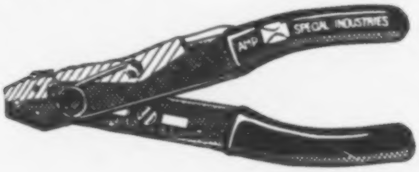
d. Soldering iron (approximately 25 W)

Figure 27



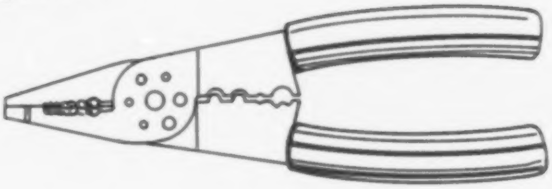
e. Adjustable wire strippers

Figure 28


AMP
SPECIAL INDUSTRIES

f. Cutting/crimping tool

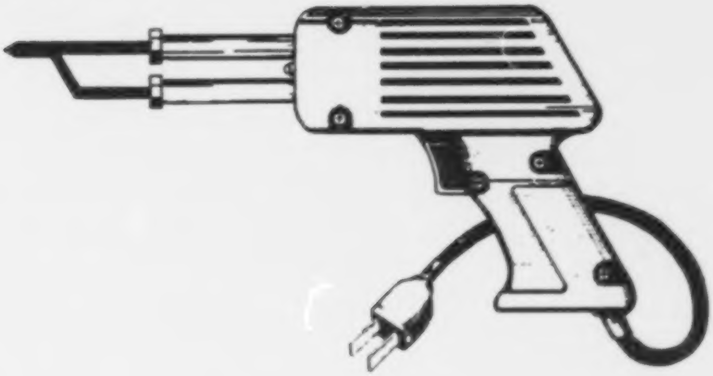
Figure 29



Information Sheet

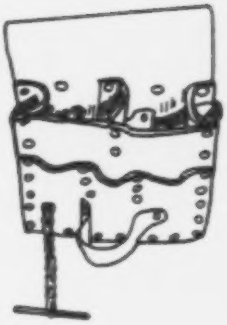
g. Soldering gun (250 W)

Figure 30



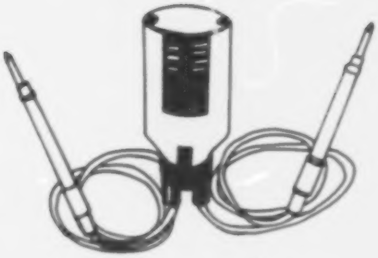
h. Tool pouch

Figure 31



i. Circuit tester

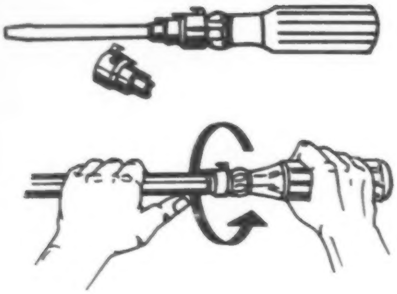
Figure 32



Information Sheet

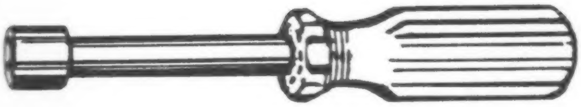
j. Conduit reamer

Figure 33



k. Nut driver

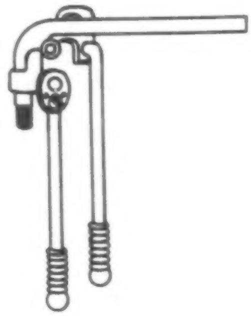
Figure 34



l. Cable bender

Note: Table 373-6(a) of the *NEC* lists space requirements for cable bending. For specific bending radii, the type of cable must be considered.

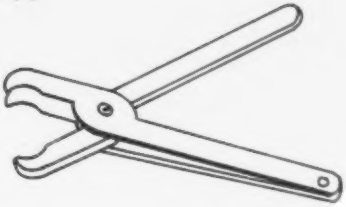
Figure 35



Information Sheet

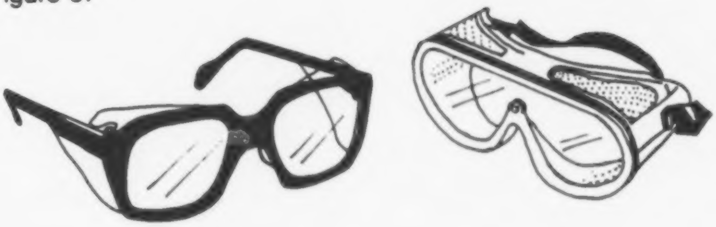
m. Fuse puller

Figure 36



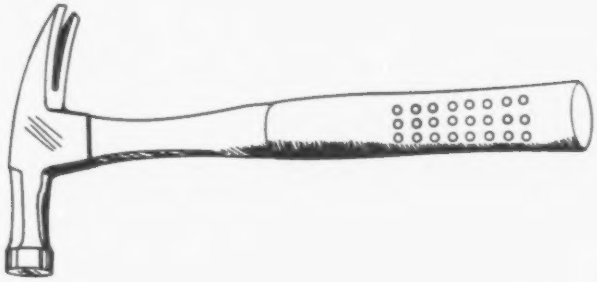
n. Safety glasses and goggles

Figure 37



o. Electrician's hammer

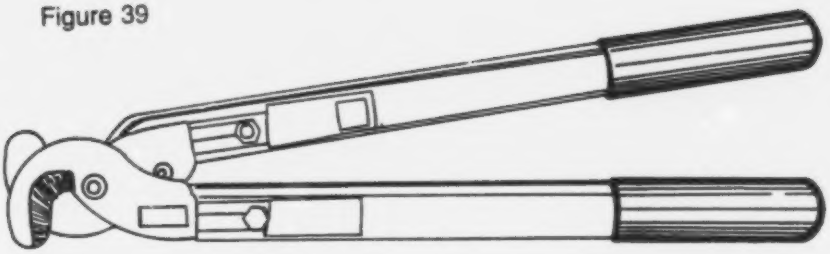
Figure 38



Information Sheet

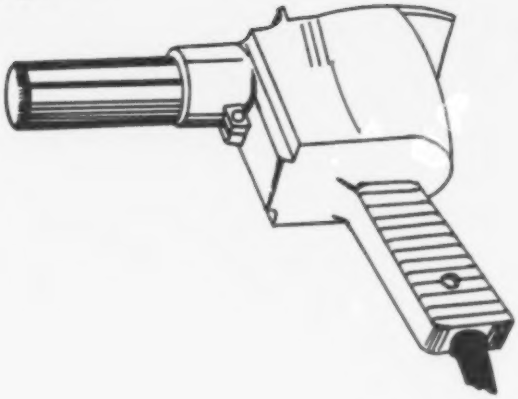
p. Cable cutter

Figure 39



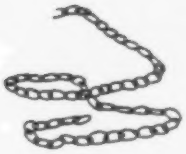
q. Heat gun

Figure 40



r. Drop chain

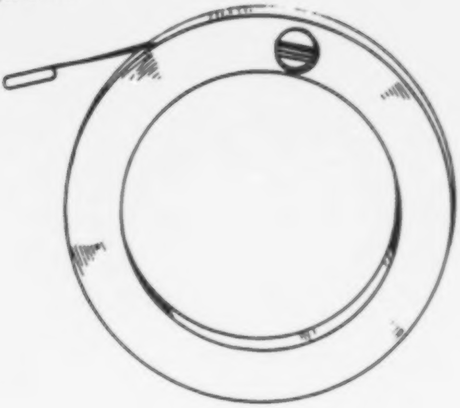
Figure 41



Information Sheet

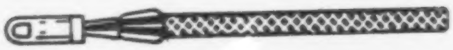
s. Steel fish tape and reel

Figure 42



t. Pulling grip-sleeve

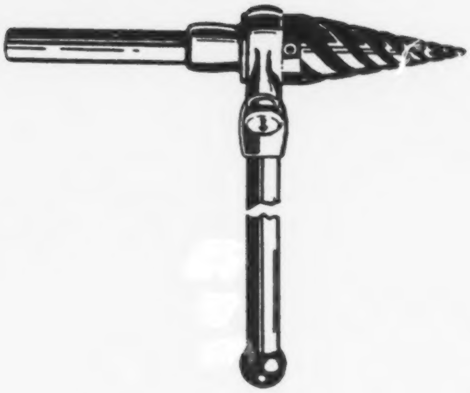
Figure 43



Information Sheet

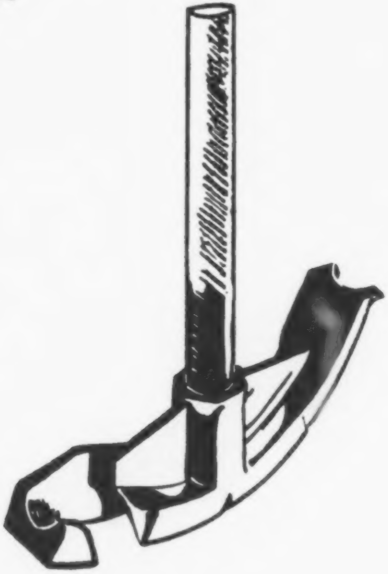
u. Pipe reamer

Figure 44



v. Combination conduit/EMT bender

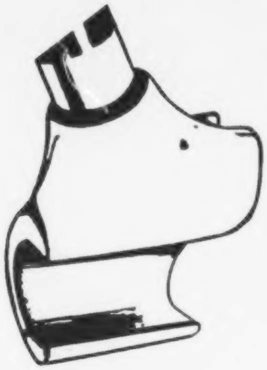
Figure 45



Information Sheet

w. Hickey bender

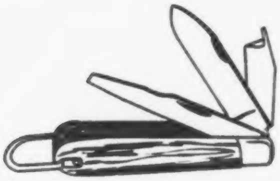
Figure 46



x. Electrician's knife

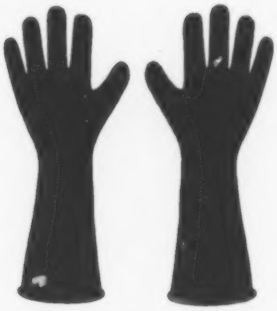
Note: All electricians and apprentices must carry a knife.

Figure 47



y. Rubber gloves

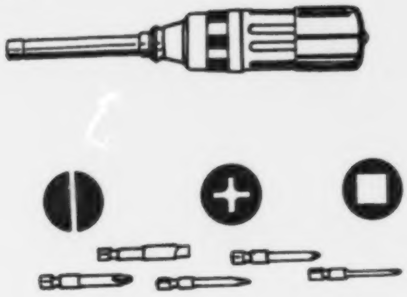
Figure 48



Information Sheet

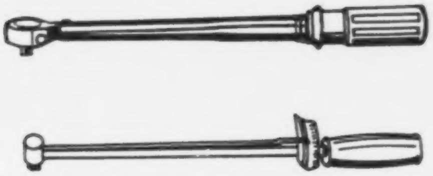
z. Torque screwdriver

Figure 49



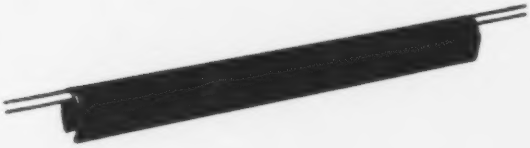
aa. Torque wrenches

Figure 50



bb. Rubber hose (line hose, snake)

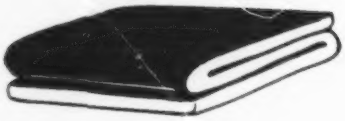
Figure 51



Information Sheet

cc. Rubber blanket

Figure 52



4. Common hand tools and their uses

a. **Folding rule or tape measure** — Measuring distances on prints, conduit, cable, and so forth

b. **Flat-blade screwdriver** — Installing and removing slot-head screws

c. **Phillips screwdriver** — Installing and removing Phillips-head screws

d. **Slip-joint pliers**

- Holding couplings and conductors
- Tightening couplings and conductors
- Holding conduit
- Tightening and turning conduit

e. **Channel-lock wrench** — Gripping and turning work; versatile

f. **Hacksaw**

- Cutting large conductors and cables
- Cutting conduit
- Cutting metal for electronic cabinets

g. **Keyhole saw** — Cutting holes in plasterboard for circuit boxes; needs no electric power

Information Sheet

h. **File**

- Deburring large conduit
- Sharpening tools
- Deburring holes in circuit boxes
- Cleaning soldering gun tips and soldering iron

i. **Chisel** — Notching wood for boxes or cables

j. **Center punch** — Making center tap for drilling

k. **Bolt cutter** — Cutting large bolts, chains, locks, and so forth

l. **Hex key set (Allen wrenches)** — Installing and removing Allen screws

m. **Magnetic torpedo level**

- Leveling conduit
- Leveling equipment

n. **Knockout punch** — Cutting large holes in metal boxes without drilling

Note: Thick or very hard metal cannot be cut with a knockout punch. Also, in some tight areas, it is inconvenient to use a knockout punch.

o. **Hole saw** — Cutting large holes in metal

p. **Drill brace and drill** — Boring holes for conduit cable

q. **Tap tool**

- Equipping drill holes with bolt threads
- Retapping damaged threads
- Determining bolt size

r. **Drill motor and drill** — Drilling holes for electronic cabinets; needs electric power

s. **Reciprocating saw** — Cutting holes in plasterboard; needs electric power

t. **Screw-holding screwdriver** — Holding screw for use in limited-space installation

Information Sheet

5. **Electricity-specific hand tools and their uses**

   a. **Needle-nose pliers**

   - Forming loops on small conductors
   - Cutting small conductors
   - Holding conductors while soldering
   - Stripping insulation from conductors when equipped with #12 stripper

   b. **Diagonal pliers (dykes)**

   - Cutting small conductors
   - Cutting conductors in limited spaces

   c. **Lineman's pliers**

   - Cutting large conductors
   - Forming loops on large conductors
   - Pulling and holding large conductors

   d. **Adjustable wire stripper**

   - Stripping insulation from conductors
   - Cutting small conductors

   e. **Cutting/crimping tool**

   - Stripping insulation from conductors
   - Cutting small conductors and bolts
   - Cutting small bolts
   - Crimping wire lugs

   f. **Soldering iron (approximately 25 W)**

   - Soldering small heat-sensitive components
   - Soldering printed circuit boards

Information Sheet

g. **Soldering gun (approximately 250 W)**

- Soldering large conductors
- Splicing cables

h. **Tool pouch**

- Holding tools
- Keeping tools organized

i. **Circuit tester**

- Checking circuits for power
- Checking fuses and breakers

j. **Conduit reamer** — Reaming burrs from cut conduits and EMT

k. **Nut driver**

- Installing and removing nuts and bolts
- Tightening and loosening nuts and long bolts

l. **Cable bender** — Assisting in bending large cables

m. **Fuse puller** — Removing fuses safely from equipment and circuit panels

Note: Fuse pullers are insulated in order to prevent shock, but power must be turned off first for safety.

n. **Safety glasses and goggles** — Protecting eyes from foreign objects and liquids

o. **Electrician's hammer**

- Driving and pulling nails
- Opening wooden crates
- Breaking plasterboard

p. **Cable cutter** — Cutting large copper or aluminum cables

Information Sheet

q. **Heat gun**

- Drying electronic components and conductors
- Heat shrinking

r. **Drop chain** — Pulling cables through wall

s. **Steel fish tape and reel**

- Pulling conductors through conduit
- Pulling cables through insulated walls

t. **Pulling grip-sleeve** — Pulling in conduit, tray, or overhead lines

u. **Pipe reamer** — Deburring conduit

v. **Conduit bender** — Bending conduit for conductor installation

w. **Hickey bender** — Bending heavy conduit

x. **Electrician's knife**

- Opening paper cartons
- Stripping large conductors
- Stripping cables
- Tightening and loosening small screws when screwdriver is not available

Note: Some electrician's knives are equipped with screwdriver blades.

y. **Rubber gloves** — Protecting wearer against electrical shock when working around energized electrical equipment

z. **Torque screwdriver** — Tightening slotted lugs and screws to manufacturer's torque specifications

aa. **Torque wrenches** — Tightening Allenhead and bolt-type lugs to manufacturer's specifications

bb. **Rubber hose (line hose, snake)** — Insulating and protecting technician from high-power, uninsulated overhead lines

Information Sheet

cc. **Rubber blanket** — Insulating and protecting technician from electrical current

Note: The blanket is laid over cabling or exposed conductor to protect the technician from accidental contact.

6. **Factors to consider when purchasing tools**

a. Size

Note: Always purchase the correct sized tool for the work to be done.

b. Design

Examples: Insulated handles, hammers with straight claws

Note: Tool should be designed specifically for electrical work.

c. Quality

Note: The purchase of quality tools saves replacement cost.

7. **Rules for care of various hand tools**

Note: All tools should be used only for the purpose intended. It is the electrician's responsibility to keep his or her tools sharp, clean, and lubricated. A well-maintained tool has a longer life and is safer than an improperly maintained tool.

a. **Screwdrivers**

- Discard worn or damaged flat-blade screwdrivers.
- Discard Phillips screwdrivers with damaged tips.

b. **Pliers**

- Keep clean and free of rust.
- Keep cutting edges sharp.
- Keep pliers working freely.
- Replace damaged handle insulation.

c. **Adjustable wrenches** — Keep worm gears clean and lubricated.

Information Sheet

d. **Cutting tools**

Examples: Saws, punches, chisels, drills, knives

- Keep cutting edges sharp
- Protect cutting edges
- Keep tools clean and lubricated.

e. **Electrically powered tools**

- Replace damaged cords.
- Do not unplug by pulling cord.
- Lubricate movable parts.
- Keep clean.
- Store properly.

Hand Tools
Unit 4

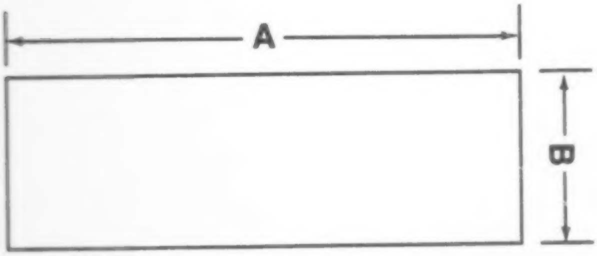
Assignment Sheet 1—Measure Objects Using a Wood Folding Rule

Name ______________________ Overall Rating __________

Evaluation criteria	**Rating**
All problems computed	______
Eight of ten answers correct per assignment sheet answers	______

Directions: Using a wood folding rule with one-sixteenth inch graduations, measure the following objects.

A.

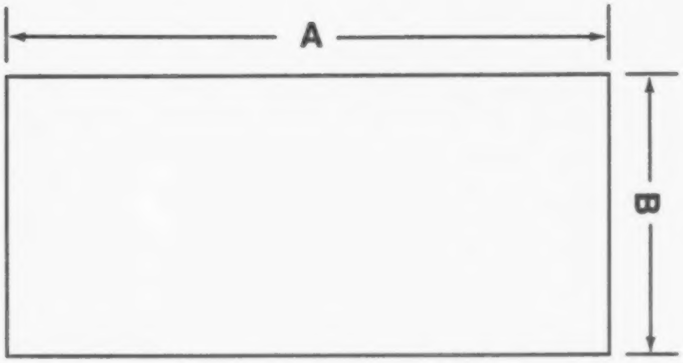


1. Length (A) __________

2. Height (B) __________

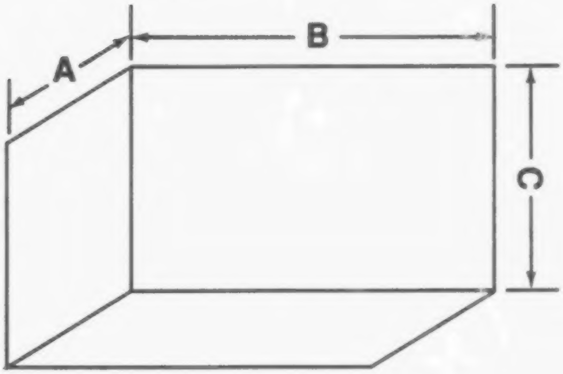
Assignment Sheet 1

B.



1. Length (A) ____________
2. Height (B) ____________

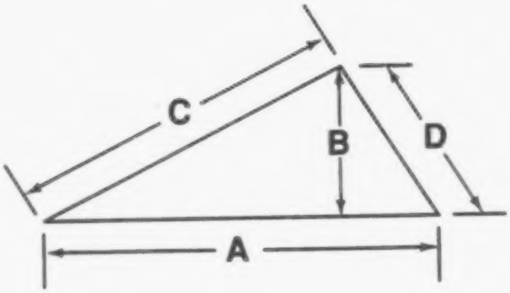
C.



1. Width (A) ____________
2. Length (B) ____________
3. Height (C) ____________

Assignment Sheet 1

D.



1. Base (A) ____________

2. Height (B) ____________

3. Slope (C) ____________

4. Slope (D) ____________

Hand Tools
Unit 4

Job Sheet 1—Clean and Lubricate an Adjustable Hand Tool

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Gathered and used appropriate equipment and materials	______
Performed procedure safely	______
Performed all steps in procedure	______
Performed steps in correct sequence	______
Cleaned work area	______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the above criteria.

A. Equipment and materials

Pliers, or other adjustable hand tool
Solvent
Oil
Protective gloves
Lint-free cleaning cloth
Rubber or plastic protective gloves
Solvent tray

Note: An old rectangular cake pan works well.

B. Procedure

☐ 1. Put on protective gloves and safety glasses.

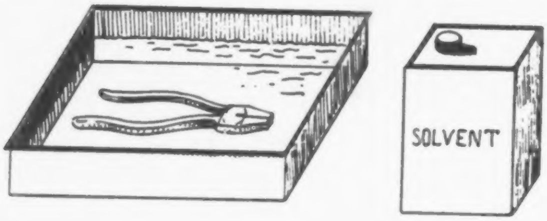
☐ 2. Lay pliers in tray.

Job Sheet 1

☐ 3. Pour solvent into tray until pliers are submerged. (Figure 1)

Note: If pliers are equipped with cushion grips, only the head should be immersed.

Figure 1



☐ 4. Open and close pliers several times while submerged.

☐ 5. Let pliers sit in solvent for 2 or 3 minutes.

☐ 6. Remove pliers from solvent.

☐ 7. Open and close rapidly until pliers work freely.

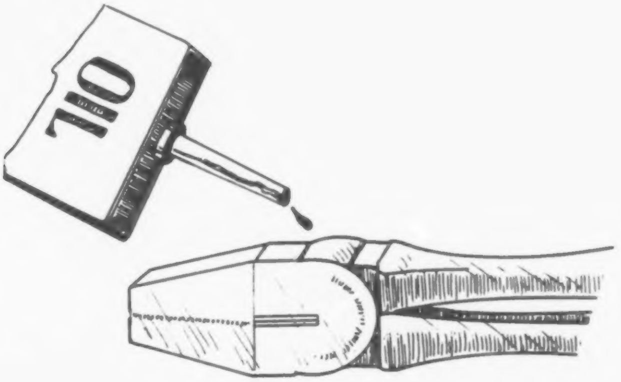
Note: If pliers will not yet work, repeat steps 1-5.

☐ 8. Wipe residue from plier joints with cloth.

Job Sheet 1

☐ 9. Apply a couple of drops of oil to joints, and work until oil has penetrated. (Figure 2)

Figure 2



☐ 10. Wipe excess oil from pliers.

Note: have instructor check tool.

☐ 11. Clean work area, and return equipment and materials to proper storage.

Evaluator's comments: ______________________________

____

____

Hand Tools
Unit 4

Job Sheet 2—Use a Cutting/Crimping Tool

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Gathered and used appropriate equipment and materials	______
Performed procedure safely	______
Performed all steps in procedure	______
Performed steps in correct sequence	______
Cleaned work area	______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the above criteria.

A. Equipment and materials

Cutting/crimping tool
Solid insulated conductor—12 to 18 gauge
Bolt—Size 6-32, 8-32, or 10-24, 10-32, 4-40
Wire-lug—Same size as conductor
Safety glasses

B. Procedure

☐ 1. Examine cutting/crimping tool.

☐ 2. Locate stripping area of the cutting/crimping tool.

☐ 3. Locate correct-sized stripping slot for conductor.

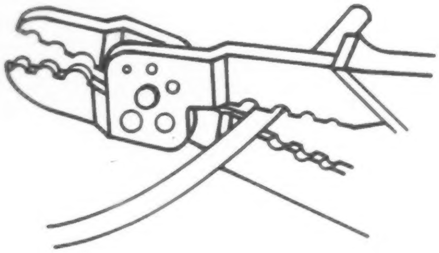
Examples: AWG-18, AWG-20 wire size

☐ 4. Put on safety glasses.

Job Sheet 2

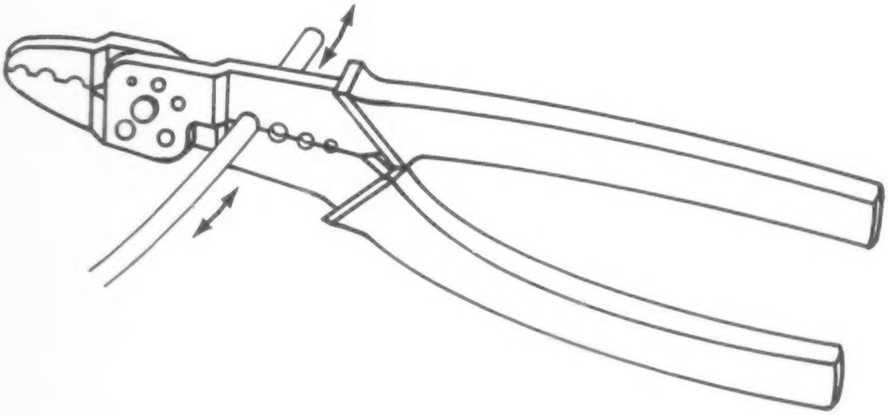
☐ 5. Open cutting/crimping tool and insert conductor into curved area of stripping slot leaving approximately ¼ inch of conductor end extending from tool. (Figure 1)

Figure 1



☐ 6. Slowly close cutting area by squeezing handles together. (Figure 2)

Figure 2

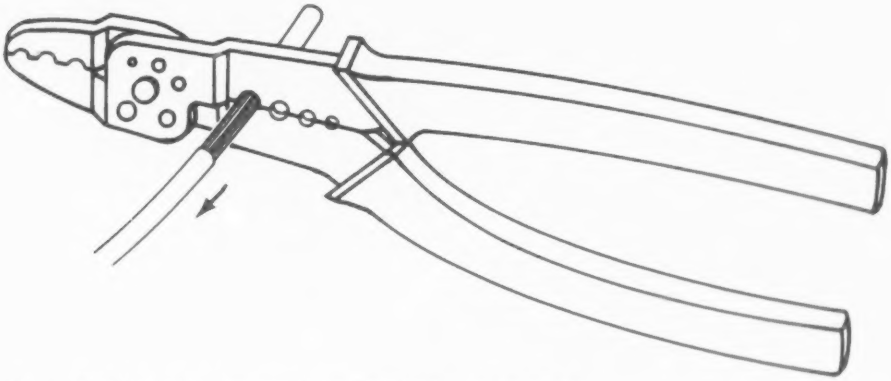


Job Sheet 2

☐ 7. Pull conductor long lead away from cutting/crimping tool. (Figure 3)

Note: If the correct stripping slot was chosen, insulation should easily slide from the conductor. Have the instructor check your work.

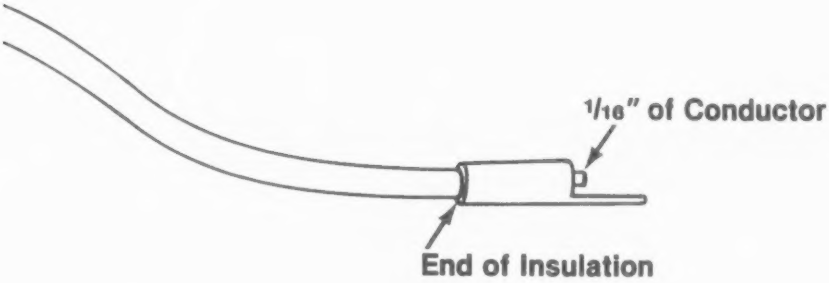
Figure 3



☐ 8. Put the wire lug on the conductor. (Figure 4)

Note: The insulation should just touch the wire lug, and the bare conductor should protrude past the wire lug approximately $\frac{1}{16}$ inch.

Figure 4



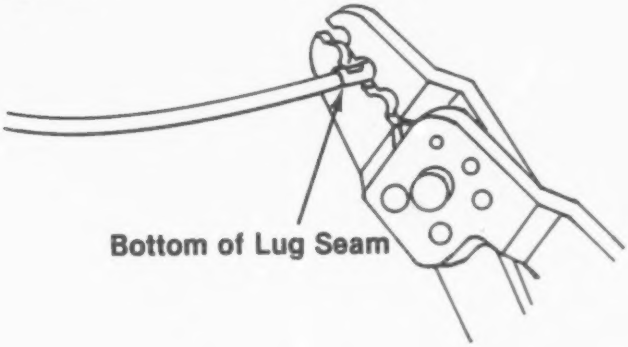
☐ 9. Locate the correct crimping area for size wire lug being used.

Note: The wire gauge number, the lug number, and the crimping tool number should all be the same. See Figure 5.

Job Sheet 2

☐ 10. Insert wire lug into crimping tool, making sure lug seam is on indenting side of crimping slot. (Figure 5)

Figure 5



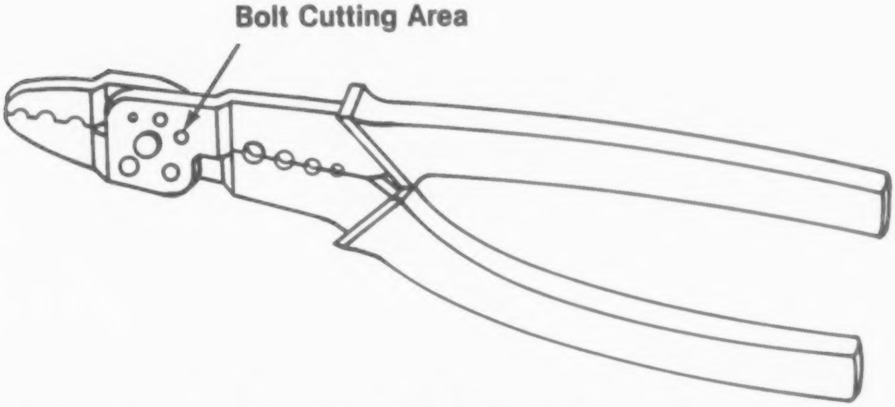
☐ 11. Squeeze the handles together to crimp the wire lug onto the conductor.

☐ 12. Remove the cutting/crimping tool.

Note: Have instructor check your work.

☐ 13. Locate the bolt cutting area of cutting/crimping tool. (Figure 6)

Figure 6



☐ 14. Locate the correct cutting slot for the bolt.

Job Sheet 2

☐ 15. Screw the bolt into the cutting hole from the screw (threaded) side of the tool.

Note: On the cutting/crimping tool, one side is threaded and the other side is unthreaded.

☐ 16. Screw the bolt into the cutting/crimping tool until the desired length is at centerpoint of cutting tool.

☐ 17. Squeeze the tool handles together until the bolt is cut.

Caution: When the bolt is cut, the unattached end may fly from cutter.

☐ 18. Remove the bolt from the cutting/crimping tool.

Note: Have the instructor check your work.

☐ 19. Clean work area, and return equipment and materials to proper storage.

Evaluator's comments: ____

____

____

Hand Tools
Unit 4

Job Sheet 3—Adjust Wire Strippers

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation criteria	Rating
Gathered and used appropriate equipment and materials	______
Performed procedure safely	______
Performed all steps in procedure	______
Performed steps in correct sequence	______
Cleaned work area	______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the above criteria.

A. Equipment and materials

Adjustable wire strippers
Screwdriver or nut driver to fit adjustment screw
Solid insulation conductor—12 or 14 gauge

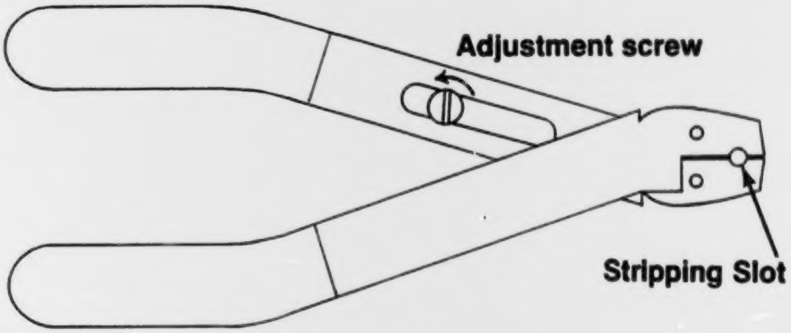
Note: Strippers should be adjusted for stripping the most commonly used conductor in your area.

Job Sheet 3

B. Procedure

☐ 1. Loosen the adjustment screw. (Figure 1)

Figure 1



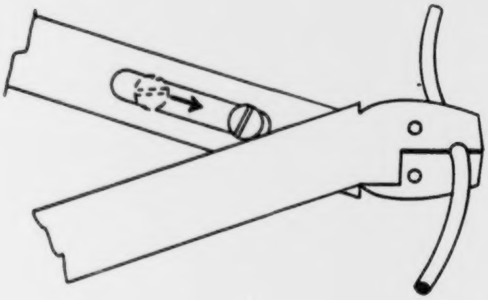
☐ 2. Insert the conductor into the stripping slot.

☐ 3. Close the stripper jaws until you feel that you have reached the conductor.

☐ 4. Open the jaws slightly.

☐ 5. Slide adjustment screw down to its resting position. (Figure 2)

Figure 2



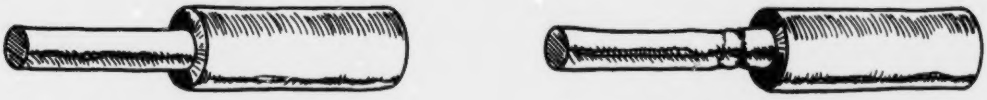
☐ 6. Strip off a fresh piece of insulation.

Job Sheet 3

☐ 7. Check the conductor for ring or nick damage. (Figure 3)

Note: If nick occurs, loosen adjustment screw, move it back slightly, retighten, and test again until insulation is cut without conductor damage. Have instructor check your work.

Figure 3



Correctly Adjusted

Incorrectly Adjusted

☐ 8. Clean work area, and return equipment and materials to proper storage.

Evaluator's comments: ____

____

____

Hand Tools
Unit 4

Job Sheet 4—Set Up and Use a Hacksaw to Cut Conduit

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation criteria	**Rating**
Gathered and used appropriate equipment and materials	______
Performed procedure safely	______
Performed all steps in procedure	______
Performed steps in correct sequence	______
Cleaned work area	______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the above criteria.

A. Equipment and materials

Needle-nose pliers
Pipe or conduit
Safety glasses
Hacksaw frame
Hacksaw blade

Note: A 24- or 32-tooth/inch blade is recommended for cutting pipe or conduit.

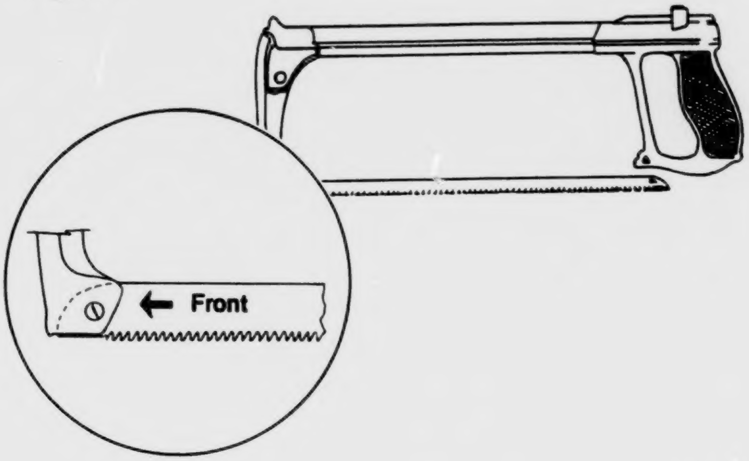
Job Sheet 4

B. Procedure

☐ 1. Put on safety glasses and gather tools and equipment.

☐ 2. Insert blade in frame, ensuring that tooth angles are pointed toward front of saw. See insert in Figure 1.

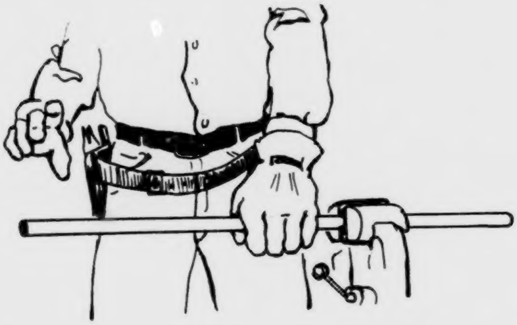
Figure 1



☐ 3. Secure pipe or conduit for cutting. (Figure 2)

Note: Short pieces of pipe are easier to cut in a vise.

Figure 2



☐ 4. Rest the hacksaw blade perpendicular to the pipe or conduit at cutting point.

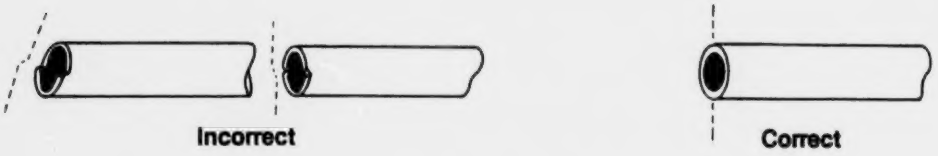
☐ 5. Push *forward* gently until cut is started, taking care not to exert extra pressure on saw.

Job Sheet 4

☐ 6. Make reciprocal strokes until cut is finished.

Note: Excessive speed while cutting can ruin blades. Do not use over thirty full strokes per minute. Your cut should be straight and relatively smooth. Figure 3.

Figure 3



Note: Have the instructor check your cut.

☐ 7. Deburr the cut end.

☐ 8. Clean work area, and return equipment and materials to proper storage.

Evaluator's comments: ______________________________

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____

Hand Tools
Unit 4

Job Sheet 5—Ream Rigid Conduit

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	Rating
Gathered and used appropriate equipment and materials	_____
Performed procedure safely	_____
Performed all steps in procedure	_____
Performed steps in correct sequence	_____
Cleaned work area	_____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the above criteria.

A. Equipment and materials

Pipe vise
Piece of rigid conduit
Safety glasses
Reamer

Note: You will need a ratchet handle or brace depending on which type reamer is used.

Job Sheet 5

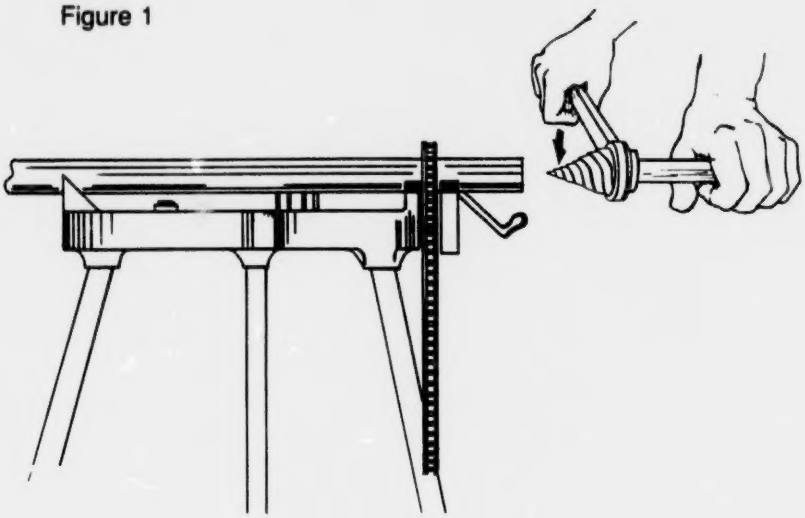
B. Procedure

Caution: Be safety conscious around cut pieces of rigid conduit. Sharp ridges or spurs can cause deep cuts.

☐ 1. Place conduit in vise

☐ 2. Insert reamer tip in conduit. (Figure 1)

Figure 1



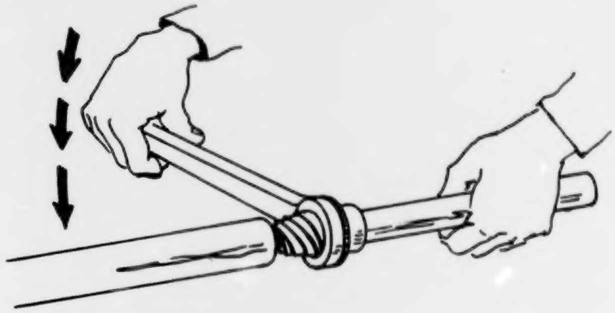
☐ 3. Apply light forward pressure to push reamer into conduit.

Job Sheet 5

☐ 4. Start rotating reamer in clockwise direction. (Figure 2)

Note: Reamer should bite instantly if proper pressure is applied. Reamer can be damaged if rotated in the wrong direction.

Figure 2



☐ 5. Rotate reamer until burrs are removed.

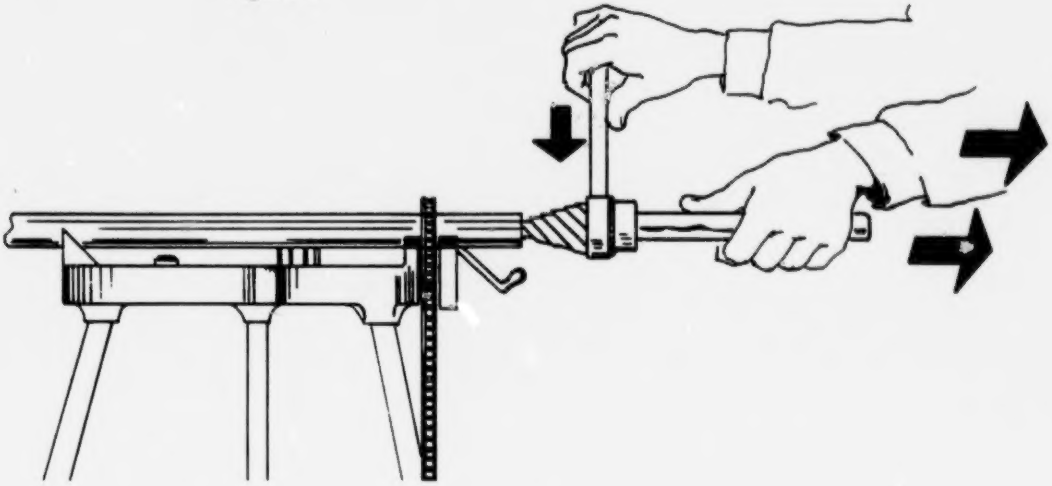
Note: This is a developed skill; the reamer can be pulled out and your progress inspected.

Job Sheet 5

☐ 6. Pull reamer back while continuing to rotate to prevent reamer from leaving a burr. (Figure 3)

Note: Have your instructor check your work.

Figure 3



☐ 7. Clean work area, and return equipment and materials to proper storage.

Evaluator's comments: ______________________________

____

____

Hand Tools
Unit 4

Job Sheet 6—Bend EMT Conduit

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	Rating
Gathered and used appropriate equipment and materials	______
Performed procedure safely	______
Performed all steps in procedure	______
Performed steps in correct sequence	______
Cleaned work area	______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the above criteria.

Note: Because of the difference in bender shoe markings, the height of this bend and its determination will be left to the instructor.

A. Equipment and materials

½-inch EMT bender
½-inch EMT (length optional)
Safety glasses
Gloves

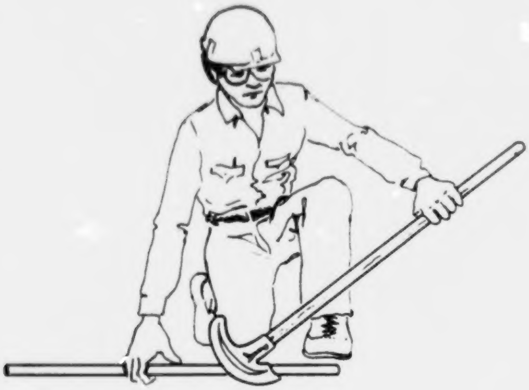
Job Sheet 6

B. Procedure

☐ 1. Put on safety glasses and gloves, and gather tools and equipment.

☐ 2. Place conduit in bender jaw. (Figure 1)

Figure 1



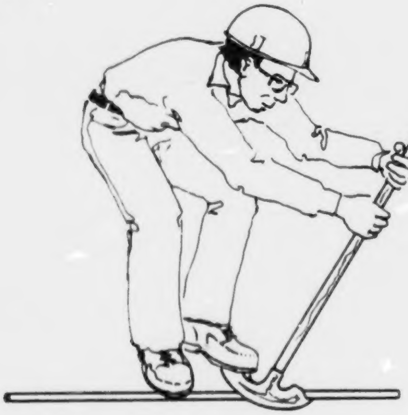
☐ 3. Apply light pressure on handle to hold conduit in place.

☐ 4. Place one foot on bender kick pad.

Job Sheet 6

☐ 5. Place other foot on conduit. (Figure 2)

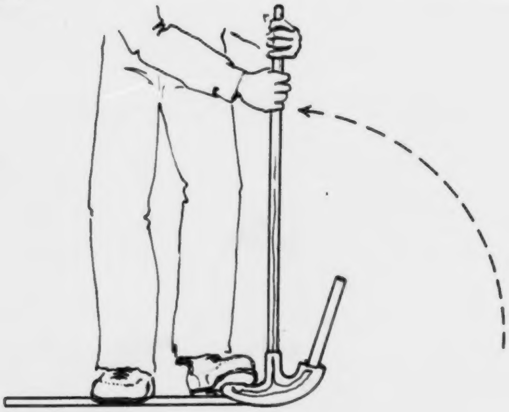
Figure 2



☐ 6. Apply heavy pressure on bender kick pad while pulling handle to a straight up position. (Figure 3)

Note: If pressure is not applied solidly to kick pad, conduit can wrinkle or collapse.

Figure 3



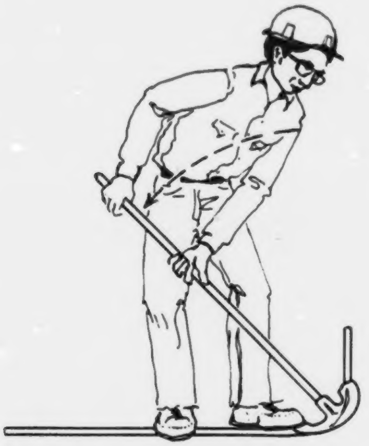
☐ 7. Reposition feet for comfort.

Job Sheet 6

☐ 8. Reapply kick pad and bender handle pressure until bend is completed. (Figure 4)

Note: A square can be used to evaluate your accuracy until you develop your skills. Have your instructor check your work.

Figure 4



☐ 9. Clean work area, and return equipment and materials to proper storage.

Evaluator's comments: ______________________________

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Hand Tools
Unit 4

Job Sheet 7—Use a Knockout Punch

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation criteria	**Rating**
Gathered and used appropriate equipment and materials	______
Performed procedure safely	______
Performed all steps in procedure	______
Performed steps in correct sequence	______
Cleaned work area	______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the above criteria.

A. Equipment and materials

Center punch
Ball peen hammer
10-inch adjustable wrench or ½-inch ratchet with socket drive to fit nut
Appropriate extension cord
Safety glasses
Gloves
Drill motor
Metal drill large enough to let the knockout punch bolt through the opening it makes
Metal to be punched

Note: Most punches are rated up to 10-gauge metal.

Vise

Note: A vise is needed when the material to be cut is not fastened to a wall or is too small to anchor by standing on it.

Job Sheet 7

B. Procedure

☐ 1. Put on safety glasses and gloves, and gather materials and equipment

☐ 2. Make an indentation in the center of the area you are going to punch.

☐ 3. Secure the drill in the drill motor, and attach motor to power source.

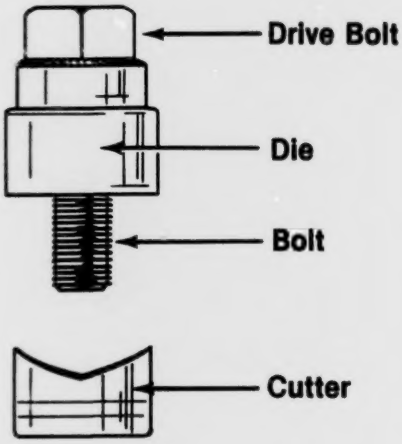
☐ 4. Place the drill tip perpendicular to the work and in the indentation you made with the center punch.

☐ 5. Holding the drill motor firmly, turn it on and drill a hole slightly larger than the KO punch bolt.

> **Caution: Hold the drill motor firmly while drilling. A loose grip can cause an accident. Remember that the drill will be hot; use caution until it cools.**

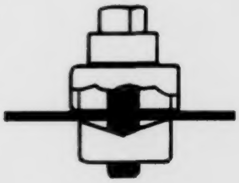
☐ 6. Separate the knockout punch cutter from the die and bolt. (Figure 1)

Figure 1



☐ 7. Insert the bolt through the drilled hole and put the cutter back on the screw. (Figure 2)

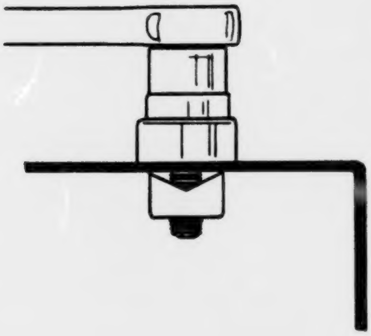
Figure 2



Job Sheet 7

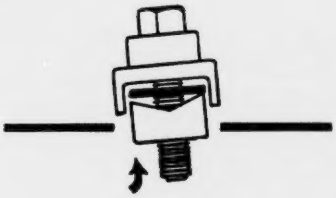
☐ 8. Tighten the drive bolt with wrench or socket. (Figure 3)

Figure 3



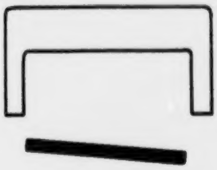
☐ 9. When the cutter is finally pulled through, remove the knockout punch. (Figure 4)

Figure 4



☐ 10. Remove the cutter from the bolt and shake out the punched metal. (Figure 5)

Figure 5



☐ 11. Lubricate cutter, if needed, and replace.

Note: Have instructor check your work.

☐ 12. Clean work area, and return equipment and materials to proper storage.

Job Sheet 7

Evaluator's comments: ______________________________

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Hand Tools
Unit 4

Job Sheet 8—Use a Hole Saw

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation criteria	Rating
Gathered and used appropriate equipment and materials	______
Performed procedure safely	______
Performed all steps in procedure	______
Performed steps in correct sequence	______
Cleaned work area	______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the above criteria.

A. Equipment and materials

Hole saw and arbor (size determined by instructor)
Drill motor
Center punch
Safety glasses
Safety gloves
Hammer
Metal to be cut

Note: Most hole saws can drill through any machinable material up to 1⅛ inches thick.

B. Procedure

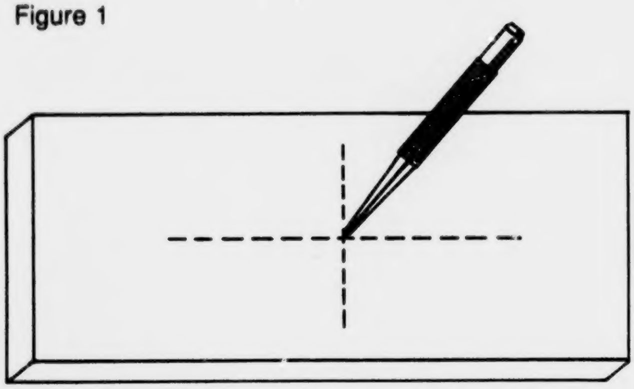
☐ 1. Put on safety glasses and gloves.

☐ 2. Locate point on metal where hole is to be cut.

Job Sheet 8

☐ 3. Place center punch on center point of hole to be cut. (Figure 1)

Figure 1



☐ 4. Strike center punch with hammer.

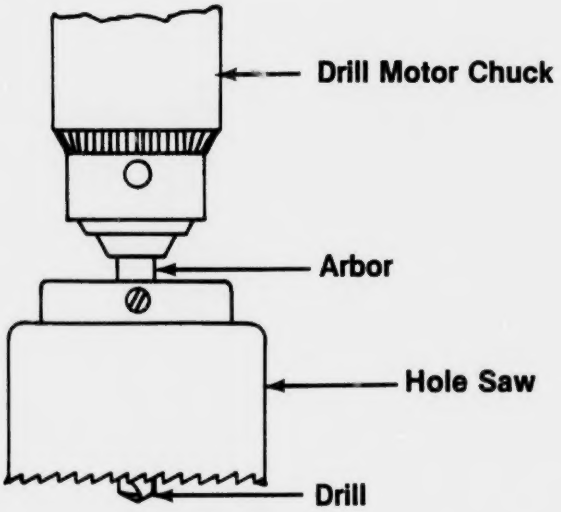
Note: How hard the center punch is stuck is determined by the type and thickness of the metal being used. If struck too hard, softer, thinner metal will bend easily.

Job Sheet 8

☐ 5. Insert hole saw arbor into the drill motor chuck. (Figure 2)

Caution: Be sure chuck is tight, and chuck key is removed before drilling.

Figure 2



☐ 6. Attach drill motor to power source.

☐ 7. Place tip of drill in hole made by the center punch.

Note: If material to be cut is not fastened solidly, put material in vise before cutting.

Caution: While drilling, hold the drill motor firmly with both hands. The hole saw can become jammed causing the drill motor to spin.

☐ 8. Turn on drill motor until hole saw has cut completely through metal being cut; use cutting oil on heavy metal.

Note: Have instructor check your work.

Job Sheet 8

☐ 9. Clean work area, and return equipment and materials to proper storage.

Evaluator's comments: ______________________________

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____

Specialty Tools and Equipment
Unit 5

Objective Sheet

Unit Objective

After completing this unit, the student should be able to identify and use common electrical specialty tools and equipment, including rules, scales, and test equipment. The student should demonstrate these competencies by completing the assignment sheets and scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to specialty tools and equipment with their correct definitions.
2. List typical power equipment.
3. Select true general safety rules for using power equipment.
4. Label the parts of a hydraulic knockout set.
5. Complete safety rules for using hydraulic knockout sets.
6. Label the parts of a hydraulic pipe bender.
7. Select true safety rules for using hydraulic pipe benders.
8. Label the parts of a polyvinylchloride (PVC) heater.
9. Complete safety rules for using polyvinylchloride heaters and blankets.
10. Label the parts of a power drill.
11. Select true safety rules for using power drills.
12. Label the parts of a power cable puller.
13. Complete safety rules for using power cable pullers.
14. Label the parts of portable and table bandsaws.
15. Complete safety rules for using portable and table bandsaws.

Objective Sheet

16. Label the parts of a dieless hydraulic crimper.
17. List safety rules for using hydraulic crimpers.
18. Label the parts of a hammer drill.
19. List safety rules for using hammer drills.
20. Label the parts of a core drilling machine.
21. Complete safety rules for using core drilling machines.
22. Label the parts of a portable power threader.
23. Complete safety rules for using power threaders.
24. Identify typical rules and scales used in the electrical industry.
25. Identify typical electrical test equipment.
26. Use an architect's scale to measure line lengths. (Assignment Sheet 1)
27. Use a hydraulic knockout punch. (Job Sheet 1)
28. Bend a 90-degree stub using a hydraulic pipe bender. (Job Sheet 2)
29. Make offset and 90-degree bends using an electric PVC heater. (Job Sheet 3)
30. Cut, ream, and thread rigid conduit with a power threader. (Job Sheet 4)
31. Measure resistance using a VOM. (Job Sheet 5)
32. Measure DC voltages using a VOM. (Job Sheet 6)
33. Measure AC voltages using a VOM. (Job Sheet 7)
34. Measure amperage using a clamp-on ammeter. (Job Sheet 8)
35. Determine the current of a multiple loop using a clamp-on-ammeter. (Job Sheet 9)
36. Check conductor insulation with a megger. (Job Sheet 10)

Specialty Tools and Equipment
Unit 5

Suggested Activities

Instructional Plan

Preparation

1. Read the unit carefully and plan for instruction. Study the specific objectives to determine the order in which you will present them.

2. Review Teaching Suggestions section that follows. Plan for classroom activities.

3. Plan your presentation to take advantage of student learning styles and to accommodate special needs students.

4. Make transparencies from the transparency masters included with this unit. The masters appear in the teacher guide only and are intended to be used with the following objectives:

   TM 1—Hydraulic Knockout Set (Objective 4)
   TM 2—Hydraulic Pipe Bender (Objective 6)
   TM 3—PVC Heater and Blanket (Objective 8)
   TM 4—Power Drill (Objective 10)
   TM 5—Hydraulic Cable Puller (Objective 12)
   TM 6—Portable and Table Band Saws (Objective 14)
   TM 7—Dieless Hydraulic Crimper (Objective 16)
   TM 8—Hammer Drill (Objective 18)
   TM 9—Core Drilling Machine (Objective 20)
   TM 10—Portable Power Threader (Objective 22)
   TM 11—Architect's Scale (Objective 24)
   TM 12—Voltage Measuring Techniques (Objective 25)
   TM 13—Permanent Magnet Moving Coil Multimeter (Objective 25)
   TM 14—Correct Voltage Measurements (Objectives 25, 32, and 33)
   TM 15—Amperage Measurement Techniques (Objectives 25 and 34)
   TM 16—Clamp-On Ammeter (Objectives 25 and 34)
   TM 17—Determining Current of a Multiple Loop Using a Clamp-On Ammeter (Objectives 25 and 35)

5. Obtain films, videotapes, and other resources to supplement instruction of this unit. See ordering information in the Suggested Supplemental Resources section that follows.

6. Develop teaching plan. Adjust for different learning styles.

7. Make copies of Unit Evaluation Form.

Suggested Activities

Delivery and Application

8. Provide students with unit of instruction.

9. Discuss unit and specific objectives.

10. Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills where applicable.

11. Discuss assignment sheets and schedule due dates. Review criteria for evaluation of this activity.

12. Discuss and demonstrate the job sheets. Review the evaluation criteria for each. Schedule performance dates.

Evaluation

13. Discuss the use of the Unit Evaluation Form with students. Select and discuss the rating scale that will be used for student evaluation.

14. Make copies of the written test. Add or modify test questions as needed.

15. Give written test.

16. Compile assignment and job sheet ratings and written test scores on the Unit Evaluation Form. Include any additional assignments.

17. Reteach and retest as required.

Teaching Suggestions

Note: Skill areas appearing in boldface type in the Teaching Suggestions refer to the academic and workplace skills identified by the American Society for Training and Development (ASTD) and the U.S. Department of Labor. These have been adapted by MAVCC.

1. Invite a local electrical tool salesperson to show specialty tools and equipment to the class. Skill area: **listening**

2. Obtain tool catalogs from various suppliers. Encourage students to compare tools and prices. Skill area: **reading, comparison/contrast, math**

3. Obtain test equipment catalogs from various suppliers. Encourage students to compare test equipment and prices. Skill areas: **reading, comparison/contrast, math**

Suggested Activities

4. Discuss with the class the proper care and maintenance of specialty tools, power equipment, and test equipment. Skill area: **listening**

5. Meet individually with students to evaluate their progress through this unit of instruction, and to indicate to them possible areas of improvement.

Resources Used in Developing This Unit

1. *Grainger Industrial and Commercial Equipment and Supplies General Catalog No. 380.* W. W. Grainger, Inc., 1991.

2. *Greenlee Products for Electrical, Electronics, HVAC, Utility, and Plant Maintenance: Tools, Testers, and Accessories Catalog.* Rockford, IL: Greenlee Textron/Subsidiary of Textron, Inc., September 1991.

3. *Rigid Catalog No. RT -191.* Elyria, OH: Rigid Tool Company, 1991.

4. Siebert, Leo N. *Introduction to Industrial Electricity-Electronics.* Stillwater, OK: Oklahoma Curriculum and Instructional Materials Center.

5. Taylor, Mark. *Residential Wiring.* Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1983.

6. Teague, Cash and Garner Pewewardy. *Industrial Electricity: In-Plant Distribution.* Stillwater, OK: Oklahoma Curriculum and Instructional Materials Center, 1984.

7. *Using Electrical Test Equipment.* Rockville, MD: NUS Training Corporation, A Halliburton Company.

Suggested Supplemental Resources

1. *Grainger Industrial and Commercial Equipment and Supplies General Catalog No. 380.* W. W. Grainger, Inc., 1991.

   Order from 4314 Will Rogers Parkway, Oklahoma City, OK 73108, or from any Grainger branch office.

2. *Greenlee Products for Electrical, Electronics, HVAC, Utility, and Plant Maintenance: Tools, Testers, and Accessories Catalog.* Rockford, IL: Greenlee Textron/Subsidiary of Textron, Inc., September 1991.

   Order from Greenlee/Textron Inc., 4455 Boeing Avenue, Rockford, IL 61109-2988 or call 1-815-397-7070

Suggested Activities

3. *Ridgid Catalog No. RT -191.* Elyria, OH: Ridge Tool Company, 1991.

   Order from Ridgid Tool Company, 400 Clark Street, Elyria, OH 44036-2023.

Instructions for Evaluating Student Performance

When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in either the teacher guide or student manual. Then observe the student performing the procedure.

> Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily achieved the step(s) for each checkpoint area. If the student is unable to correctly complete the procedure, have the student review the materials and try again.
>
> Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria which have been provided as part of the job sheet. Complete the rating by assigning a point value to each criterion and by converting the point total to a percentage for grading. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) which best fits your program needs.

Option A

4 - Skilled—Can perform job with no additional training.
3 - Moderately skilled—Has performed job during training program; limited additional training may be required.
2 - Limited skill—Has performed job during training program; additional training is required to develop skill.
1 - Unskilled—Is familiar with process, but is unable to perform job.

Option B

Yes—Can perform job with no additional training.

No—Is unable to perform job satisfactorily.

Specialty Tools and Equipment
Unit 5

Answers to Assignment Sheet

Assignment Sheet 1

A. 65′
B. 38′6″
C. 15′11″
D. 23′6″
E. 10′10½″
F. 3′5″
G. 1′6½″
H. 1′9½″
I. 2′11″
J. 2′

Specialty Tools and Equipment
Unit 5

Answers to Written Test

1.
   a. 22
   b. 20
   c. 19
   d. 21
   e. 18
   f. 14
   g. 16
   h. 10
   i. 17
   j. 13
   k. 8
   l. 9
   m. 5
   n. 3
   o. 2
   p. 1
   q. 6
   r. 7
   s. 4
   t. 11
   u. 12
   v. 15

2.
   a. Hydraulic knockout
   b. Hydraulic bender
   c. Electric PVC heater
   d. Power drill
   e. Power threader

3. b, c, d, e

4.
   a. Hydraulic pump
   b. Hydraulic hose
   c. Knockout cutter
   d. Die
   e. Hydraulic threaded ram
   f. Screw sleeve
   g. ½-inch knockout adapter
   h. Spacers

5.
   a. Hydraulic oil
   b. Under pressure
   c. Live
   d. Force

6.
   a. Hydraulic pump
   b. Hydraulic hose
   c. Ram travel gauge
   d. Hydraulic ram
   e. Pipe
   f. Bender frame
   g. Bender shoe
   h. Pipe support

7. b, c, d, e, g

Answers to Written Test

8. a. Carrying handle
   b. Heater outer case
   c. Door
   d. Heating element
   e. Pipe rollers
   f. Insulated door handle
   g. On/off switch

9. a. Wet
   b. Gloves
   c. PVC
   d. Always
   e. Conduit
   f. Well-ventilated
   g. Unattended
   h. Hot surfaces

10. a. Cross handle
    b. Chuck key
    c. Chuck
    d. Power trigger
    e. Reverse/forward switch
    f. Drill motor

11. b, d, f, h

12. a. Right-angle sheave
    b. Tapered capstan
    c. Rope guide
    d. Motor
    [illegible] Force gauge
    [illegible] Power cord
    g. Mounting chains

13. a. Load
    b. Manufacturer's
    c. Force
    d. Exceed
    e. Eye

Answers to Written Test

14. **Portable Band Saw**
    - a. Blade band
    - b. Blade tension adjustment lever
    - c. Forward handle grip
    - d. Motor
    - e. Handle grip on/off trigger
    - f. Blade angle adjustment
    - g. Stock stop

    Table Band Saw
    - a. Table foot brake
    - b. Motor
    - c. Band saw
    - d. Adjustable keeper
    - e. On/off switch
    - f. Keeper adjustment handle
    - g. Work table

15.
    - a. Vise
    - b. Teeth
    - c. Safety guards
    - d. Hands

16.
    - a. Dieless, hinged crimping head
    - b. Hydraulic pump handle
    - c. Hydraulic pump
    - d. Swivel

17.
    - a. Ensure that die is mounted securely on threading machine.
    - b. Keep die flooded with cutting oil during operation.
    - c. Keep hands, clothing, and hair away from rotating parts.
    - d. Always wear eye protection.

18.
    - a. Variable speed switch
    - b. T-handle front grip
    - c. Chuck
    - d. Depth gauge
    - e. Hammer selector
    - f. Motor
    - g. On/off trigger
    - h. Reverse button
    - i. Power cord
    - j. Masonry and steel drill bits

Answers to Written Test

19.
   a. Always hold the drill steady and perpendicular to the work to prevent the bit from breaking or binding.
   b. Always use a T-handle when drilling to allow you to secure the hammer drill when it encounters especially hard surfaces.
   c. Never lock the trigger in the "on" position.
   d. Never drill while off balance.
   e. Always wear eye protection.

20.
   a. Vacuum pump
   b. Anchor base
   c. Spindle shaft for bit
   d. Drill motor
   e. Mast
   f. Motor height adjustment handle
   g. Air hose
   h. Pressure gauge
   i. Air filter/dryer
   j. Core bits

21.
   a. Surface to be drilled
   b. Drilling
   c. Faster

22.
   a. Pipe chuck
   b. Threader head
   c. Forward handle grip
   d. Motor
   e. Handle
   f. Power cord
   g. Pressure on/off switch
   h. Die

23.
   a. Eye protection
   b. Tight-fitting, long hair
   c. Gloves
   d. Hands
   e. Reversing direction
   f. Brush
   g. Off balance

24.
   a. Folding rule
   b. Architect's scale

25.
   a. Voltage tester
   b. Multimeter (VOM)
   c. Clamp-on ammeter
   d. Megometer (megger)

320

Specialty Tools and Equipment
Unit 5

Written Test

Name ______________________________ Score ______________

1. Match terms related to specialty tools and equipment with their correct definitions. Write the correct numbers in the blanks. Definitions are continued on the next page.

_____a. Electromotive force (emf) that drives electricity through conductors; must be measured across or referenced to a second point.

_____b. Opposition to electrical current flow; measured in units of ohms; must be measured from one point to another

_____c. Device used to transfer hydraulic pressure to a mechanical device

_____d. How well an instrument will indicate a small change in the measured value

_____e. Instrument consistency

_____f. Instrument capable of measuring a "multiple" of values

_____g. Any opening that may close and bind a finger or hand

_____h. Electrical point or any good conductor that is connected to a common chassis with zero relative voltage; usually conductors are connected to the earth

_____i. Plastic pipe

_____j. Device used to make openings for conduit in metal enclosures

_____k. Component that backs up cutter on opposite side of metal box

1. Accuracy
2. Amperage
3. Bender
4. Calibration
5. Chuck
6. Cross handle (T-handle)
7. Cutter
8. Die
9. Error
10. Ground
11. Hydraulic
12. Hydraulic oil
13. Knockout punch
14. Multimeter
15. Parallax correction
16. Pinch point
17. Polyvinylchloride (PVC) conduit

Written Test

______l. How far a measurement is from the actual value

______m. Portion of drill that holds the bit

______n. Tool used to make various angles or bends in conduit

______o. Electricity; electrical current flow; electron flow; must be measured at a point within a circuit

______p. How near the instrument reading is to the actual value

______q. Handle set across a power tool to prevent the tool from turning

______r. Hardened steel device used to cut holes in metal boxes

______s. Technique of testing and adjusting an instrument by referring it to another instrument or device of known accuracy and precision

______t. Using pressurized fluid to accomplish work

______u. Specially formulated oil for hydraulic pumps

______v. Viewing analog VOM from directly above the needle to avoid the possibility of wrong readings due to depth perception

18. Precision
19. Ram
20. Resistance
21. Resolution
22. Voltage

Written Test

2. List typical power equipment below.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

f. ______________________________

g. ______________________________

h. ______________________________

i. ______________________________

j. ______________________________

3. Select true general safety rules for using power equipment. Write an "X" in the blank before each true rule.

______a. Follow manufacturer's operating instructions when possible.

______b. Never place hands in pinch point.

______c. Use eye protection.

______d. Wear gloves when working with hot equipment or materials.

______e. Always secure loose clothing such as shirt sleeves and shirttails.

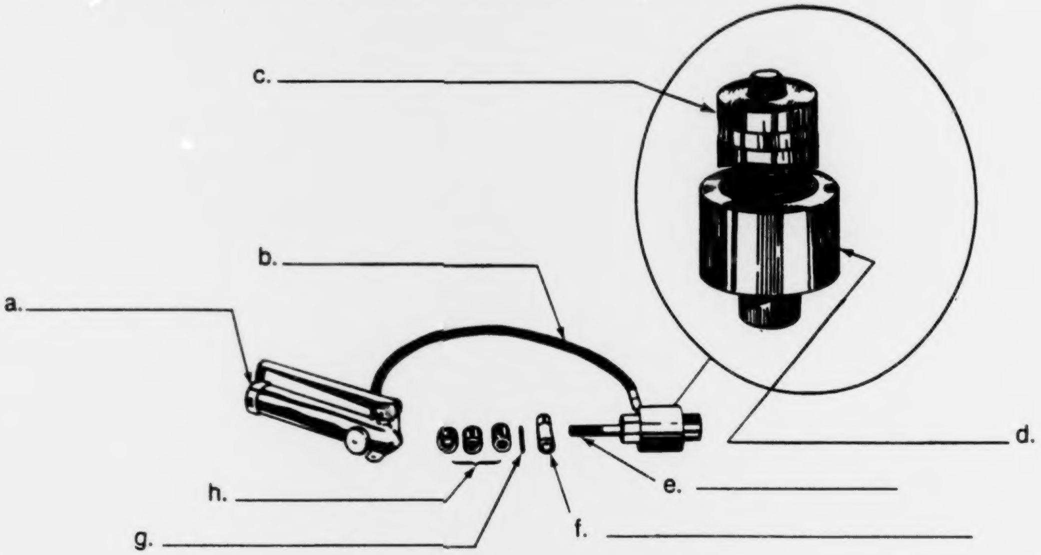
______f. Exceed rated capacity of equipment if you are behind schedule.

______g. Leave running equipment unattended.

______h. Remove protective guards from equipment when they get in the way.

Written Test

4. Label the parts of the hydraulic knockout set illustrated below.



5. Complete safety rules for using hydraulic knockout sets. Write the word(s) that best completes each statement.

   a. Never substitute brake fluid for ____________ ____________.

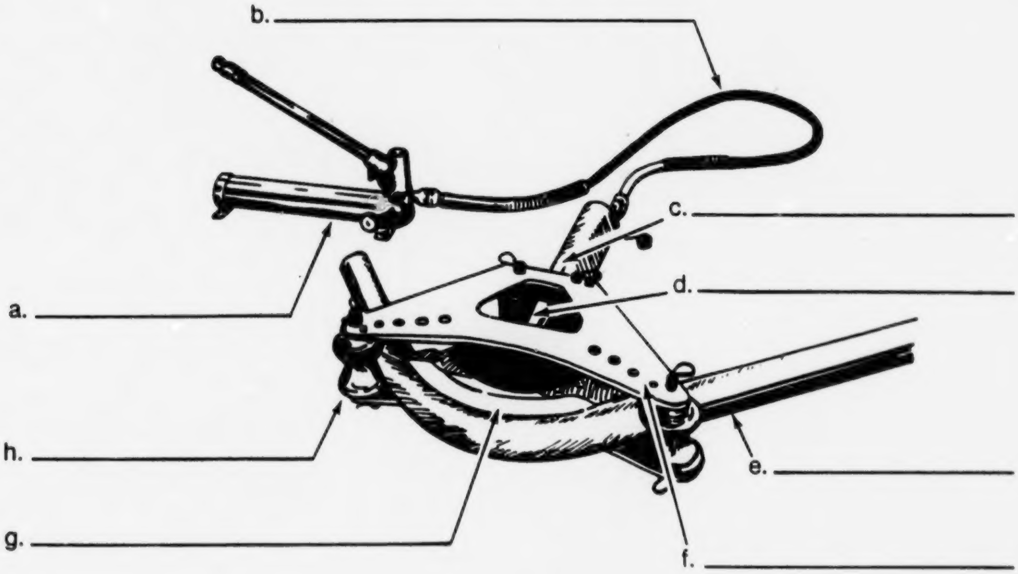
   b. Never disconnect hose when it is ____________ ____________.

   c. Do not use near ____________ electrical parts.

   d. Never ____________ pump handle.

Written Test

6. Label the parts of the hydraulic pipe bender illustrated below.



7. Select true safety rules for using hydraulic pipe benders. Write an "X" in the blank before each true rule.

______a. Substitute brake fluid for hydraulic oil.

______b. Never disconnect hose when it is under pressure.

______c. Never place hands near ram or shoe while bending.

______d. Always use proper size conduit shoe and support.

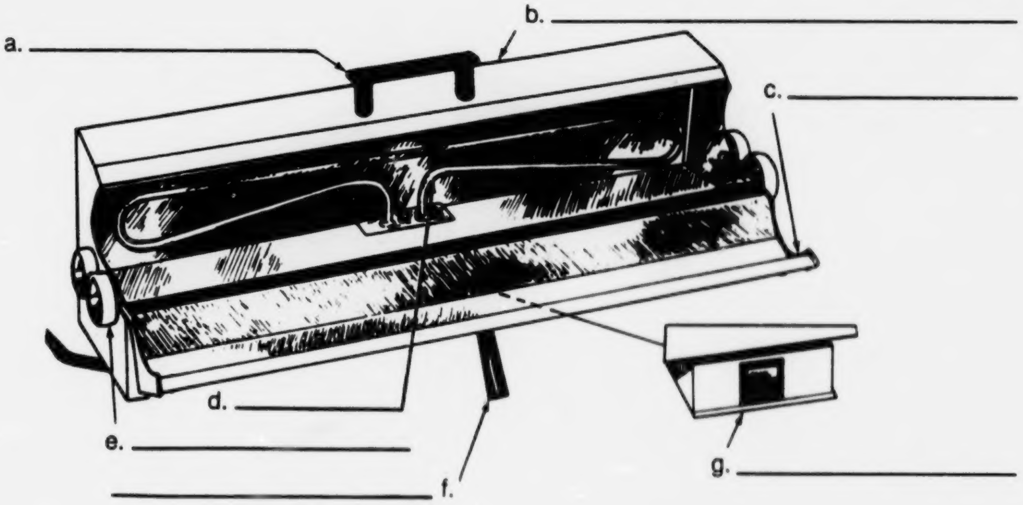
______e. Be sure that floor area is clear for pipe movement.

______f. Lift heavy bender parts correctly.

______g. Make sure that shoe, follow bar, saddle, pipe support, and other accessories are appropriate for the size and type hydraulic pump used.

Written Test

8. Label the parts of a polyvinylchloride (PVC) heater illustrated below.



9. Complete safety rules for using electric polyvinylchloride (PVC) heaters and blankets. Circle the word that best completes each rule.

   a. Never use in (dry, wet) locations.

   b. Always wear (safety shoes, gloves) when handling hot heater or pipe.

   c. Use only with (PVC, EMT) conduit.

   d. (Always, Occasionally) turn bender off when not in use.

   e. Use only for specified type and size (conduit, heating element).

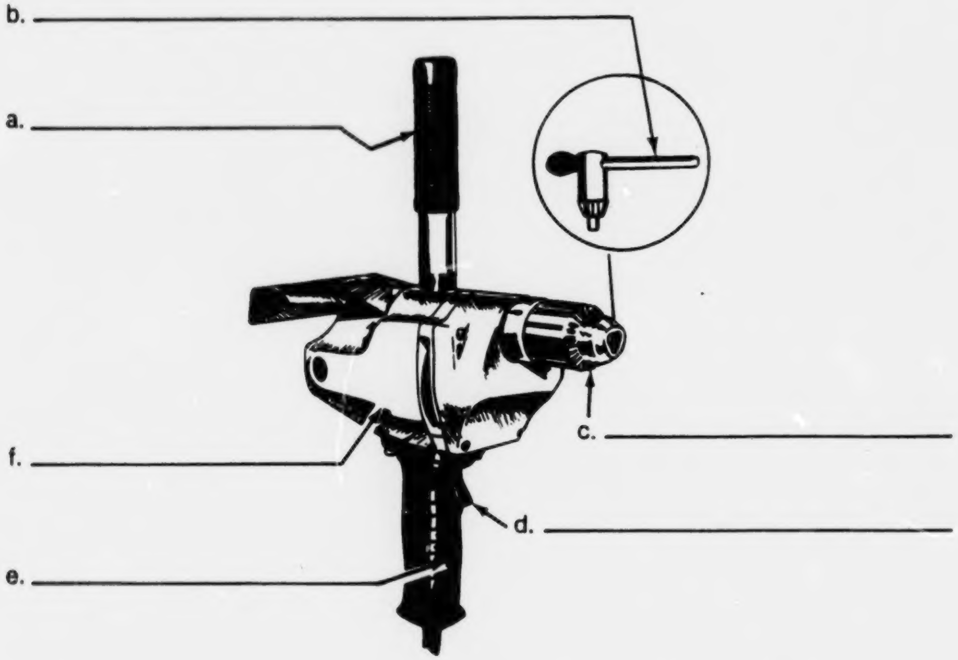
   f. Use only in a (sprinklered, well-ventilated), noncluttered area.

   g. Never leave (attended, unattended) while turned on.

   h. Keep hands and other body parts from direct contact with (hot surfaces, electrical cord).

Written Test

10. Label the parts of the power drill illustrated below.



11. Select true safety rules for using power drills. Write an "X" in the blank before each true rule.

______a. Always wear gloves.

______b. Check area to be drilled for hidden wires or pipes.

______c. Hold drill securely with one hand.

______d. Never drill while off balance.

______e. Place all objects to be drilled in a vise.

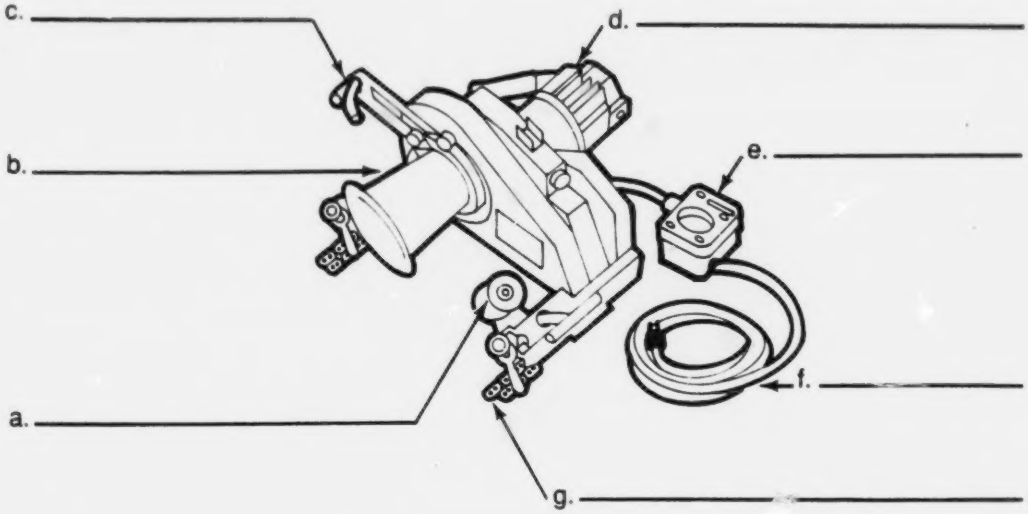
______f. Always use a T-handle when drilling.

______g. **Never** lock the trigger in the "off" position.

______h. Always wear eye protection.

Written Test

12. Label the parts of the hydraulic cable puller illustrated below.



13. Complete safety rules for using hydraulic cable pullers. Circle the word that best completes each rule.

    a. Ensure that all cable pulling systems, accessories, and rope have the proper (weight, load) rating for the pull.

    b. Mount and secure pulling unit according to (manufacturer's, *NEC*) instructions.

    c. Stand out of direct line of (work, force).

    d. Monitor pull on (rope fibers, force gauge), and never (exceed, reach) maximum force.

    e. Always wear (ear, eye) protection.

Written Test

14. Label the parts of the portable and table band saws below.

Portable Band Saw

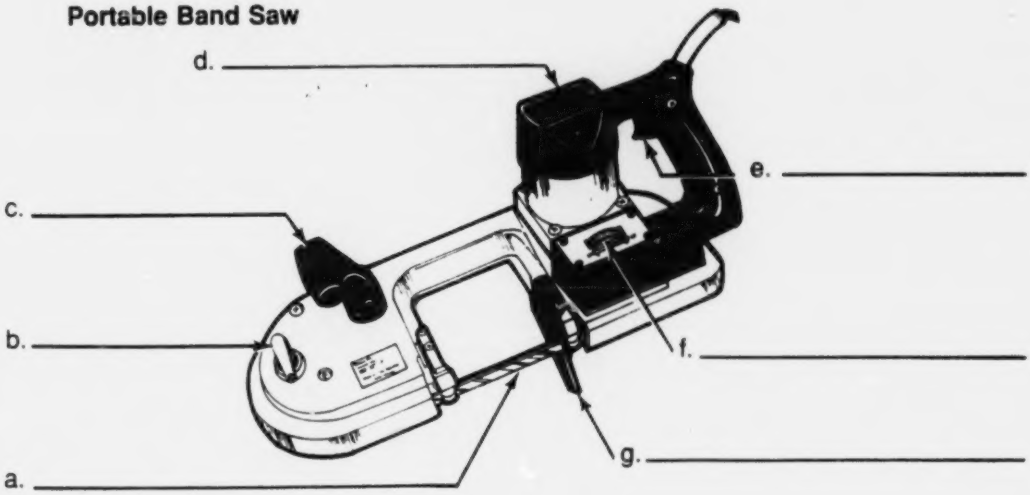
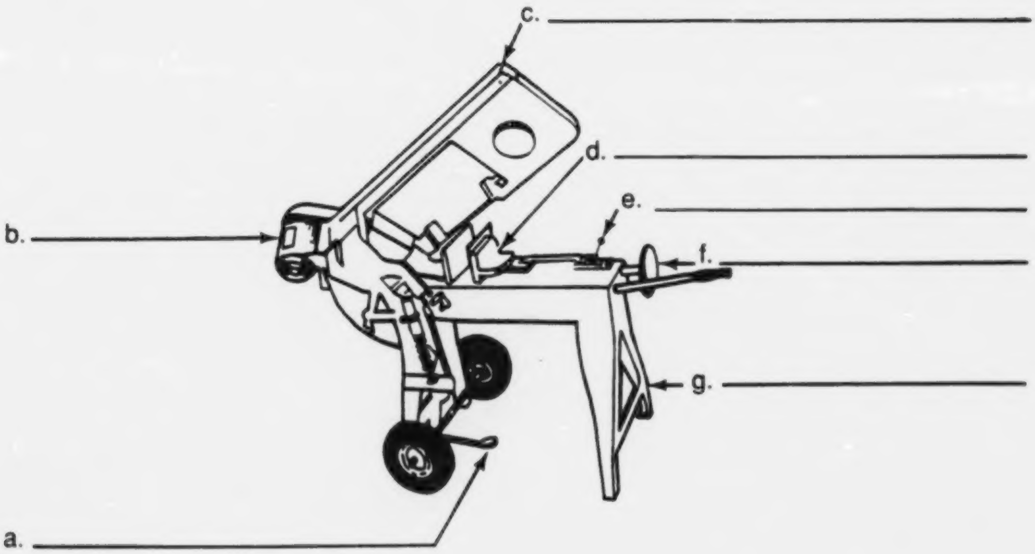


Table Band Saw



Written Test

15. Complete safety rules for using portable and table bandsaws.

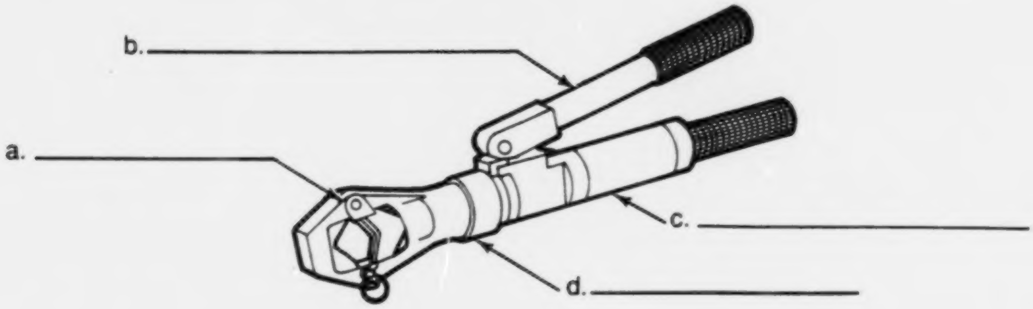
    a. Secure object to be cut in a (c-clamp, vise) or other stable rest.

    b. Check the blade for missing (teeth, oil film) that could result in the blade binding or breaking.

    c. Do not remove or alter (safety guards, saw blade).

    d. Keep (hands, work) clear of the blade.

16. Label the parts of the dieless hydraulic crimper below.



17. List safety rules for using hydraulic crimpers.

    a. ____

    ____

    b. ____

    ____

    c. ____

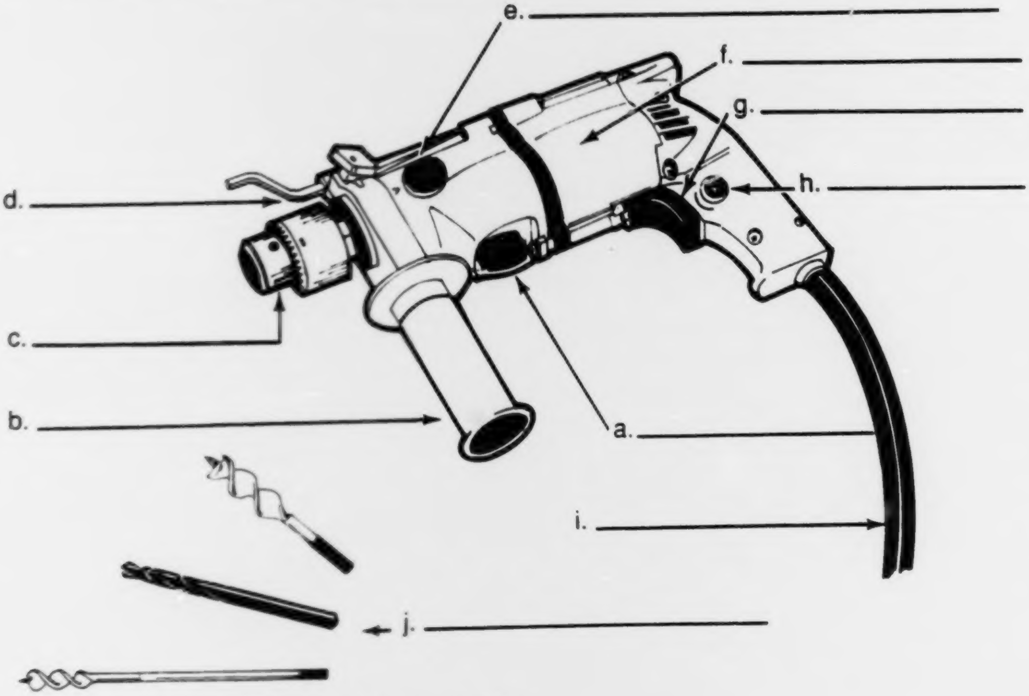
    ____

    d. ____

    ____

Written Test

18. Label the parts of the hammer drill illustrated below.



19. List safety rules for using hammer drills.

a.

b.

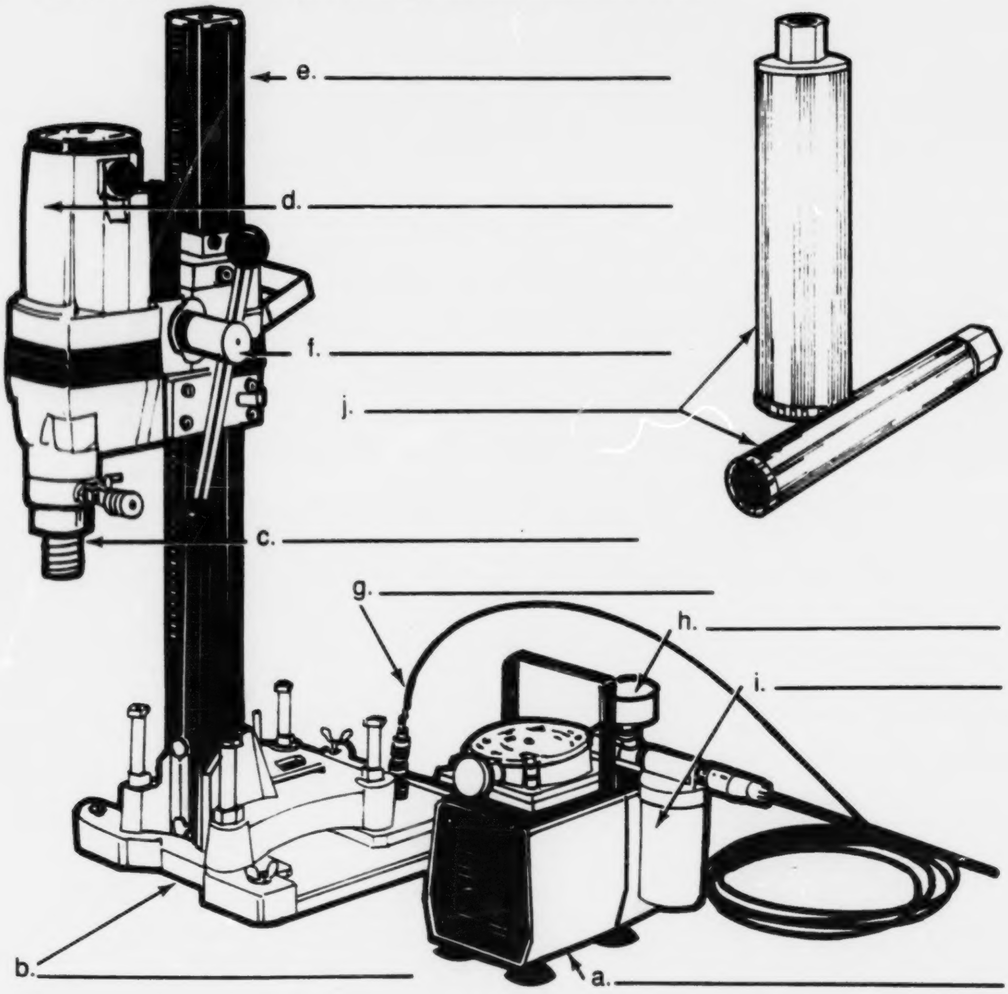
c.

d.

e.

Written Test

20. Label the parts of the core drilling machine illustrated below.



21. Complete safety rules for using core drilling machines. Circle the word that best completes each rule.

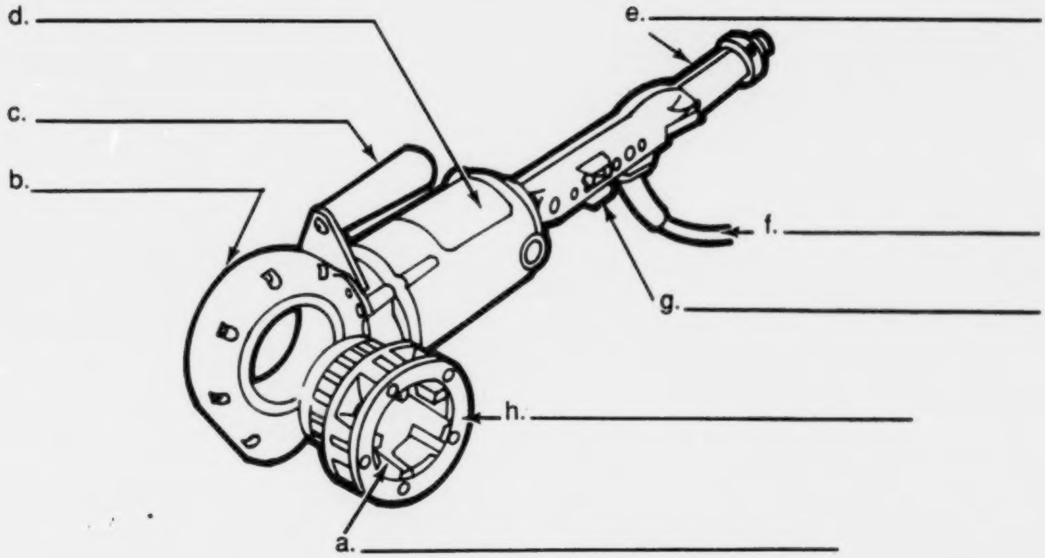
    a. Ensure that the core drilling machine is securely mounted to the (support table, surface to be drilled).

    b. Never leave the machine (mounted, drilling) while unattended.

    c. Do not try to force the drill to cut (faster, deeper) than suggested by the manufacturer.

Written Test

22. Label the parts of the portable power threader illustrated below.



23. Complete the following statements concerning specific safety rules for using power threaders. Write the word(s) that best completes each statement.

a. Always wear ________________.

b. Always wear ________________ clothing, tie back ________________ ________________, and remove dangling jewelry.

c. Use ________________ when handling pipe/conduit.

d. Never place ________________ near turning pipe/conduit.

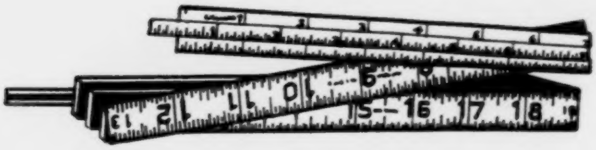
e. Let threader come to a complete stop before removing pipe/conduit or ________________ ________________.

f. Always use a ________________ to clear thread cuttings.

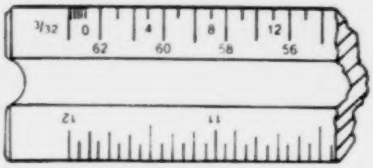
g. Never operate the threader while ________________ ________________.

Written Test

24. Identify the typical rules and scales illustrated below. Write the correct name below each illustration.



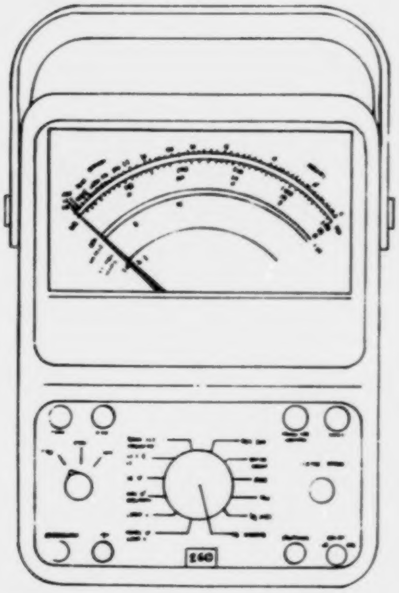
13
12
11
10
15
16
17
18

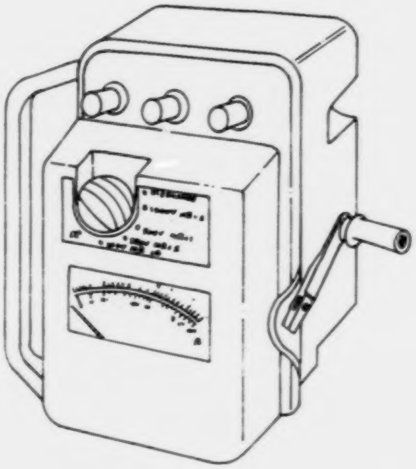


3/32
0
4
8
12
62
60
58
56
12
11

a. ______________________ b. ______________________

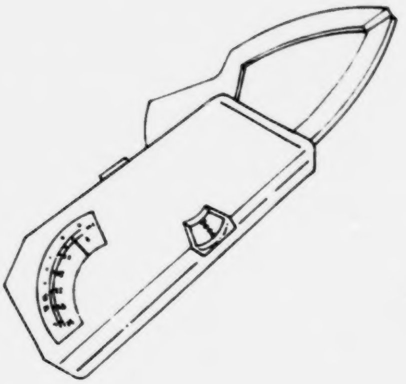
25. Identify the typical test equipment illustrated below. Write the correct name below each illustration.



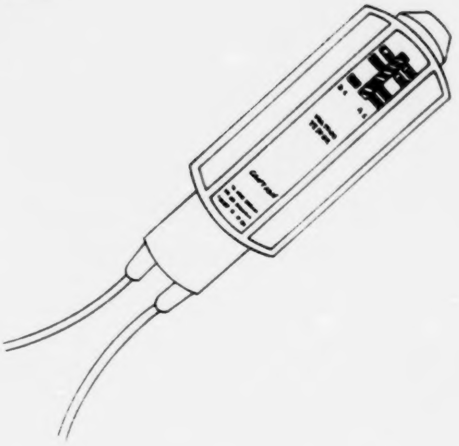


a. ______________________ b. ______________________

Written Test



c. ______________________________



d. ______________________________

*Permission to duplicate this test is granted.

Specialty Tools and Equipment
Unit 5

Unit Evaluation Form

Student Name ______________________________ Unit Rating __________

Assignment Sheet 1—Use an Architect's Scale to Measure Line Lengths Rating ______

Comments: ____

____

Job Sheet 1—Use a Hydraulic Knockout Punch Rating ______

Comments: ____

____

Job Sheet 2—Bend a 90-Degree Stub Using a Hydraulic Pipe Bender Rating ______

Comments: ____

____

Job Sheet 3—Make Offset and 90-Degree Bends Using an Electric PVC Heater Rating ______

Comments: ____

____

Job Sheet 4—Cut, Ream, and Thread Rigid Conduit with a Power Threader Rating ______

Comments: ____

____

Job Sheet 5—Measure Resistance Using a VOM Rating ______

Comments: ____

____

Unit Evaluation Form

Job Sheet 6—Measure DC Voltages Using a VOM Rating ______

Comments: ______________________________

____

Job Sheet 7—Measure AC Voltages Using a VOM Rating ______

Comments: ______________________________

____

Job Sheet 8—Measure Amperage Using a Clamp-On Ammeter Rating ______

Comments: ______________________________

____

Job Sheet 9—Determine the Current of a Multiple Loop Using a Clamp-On Ammeter Rating ______

Comments: ______________________________

____

Job Sheet 10—Check Conductor Insulation with a Megger Rating ______

Comments: ______________________________

____

Written Test Scores

Pretest ______ Posttest ______ Other ______

Other ______________________________

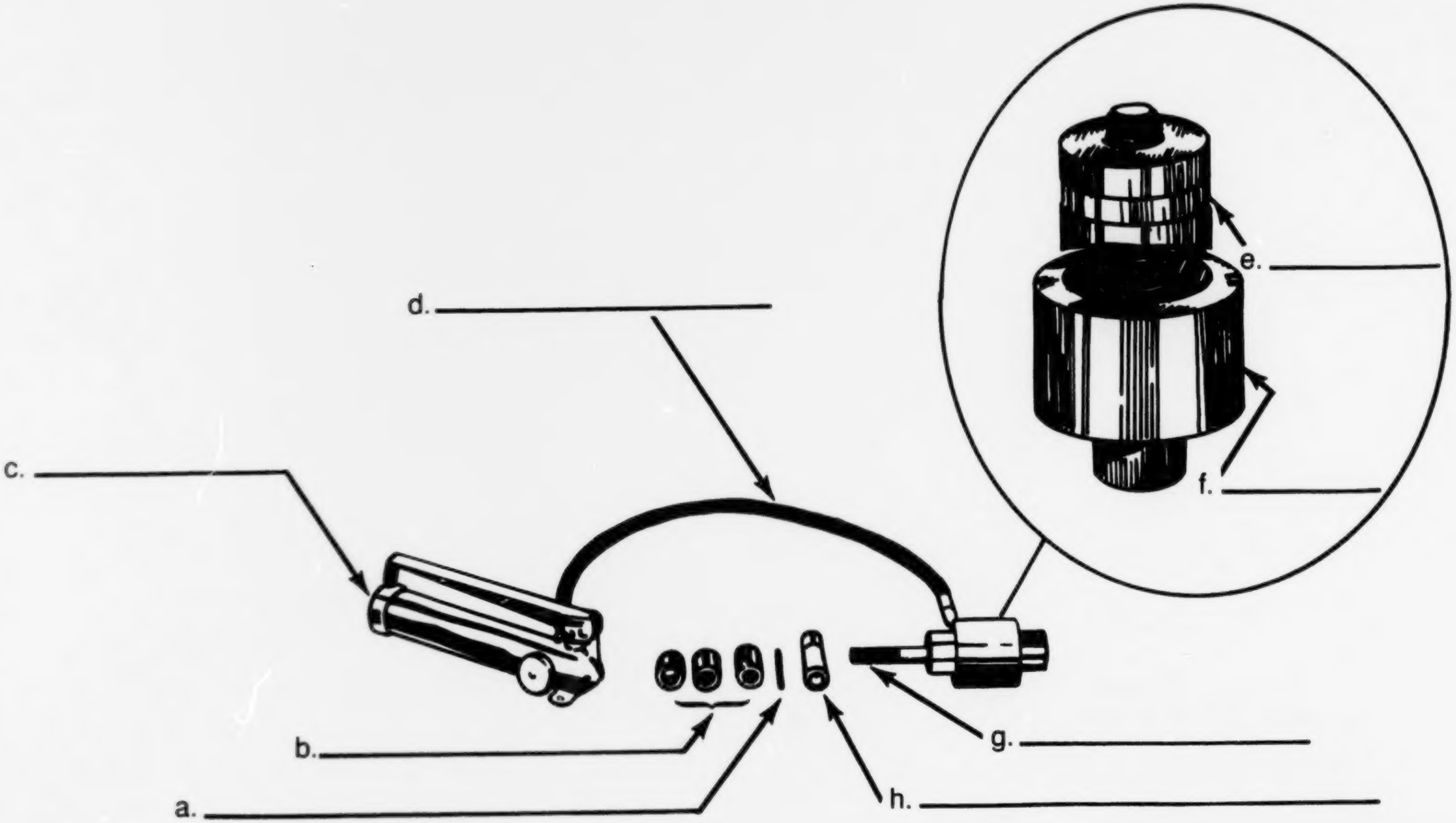
____

Teacher Signature ______________________________ Date ______________

Student Signature ______________________________ Date ______________

***Permission to duplicate this form is granted.**

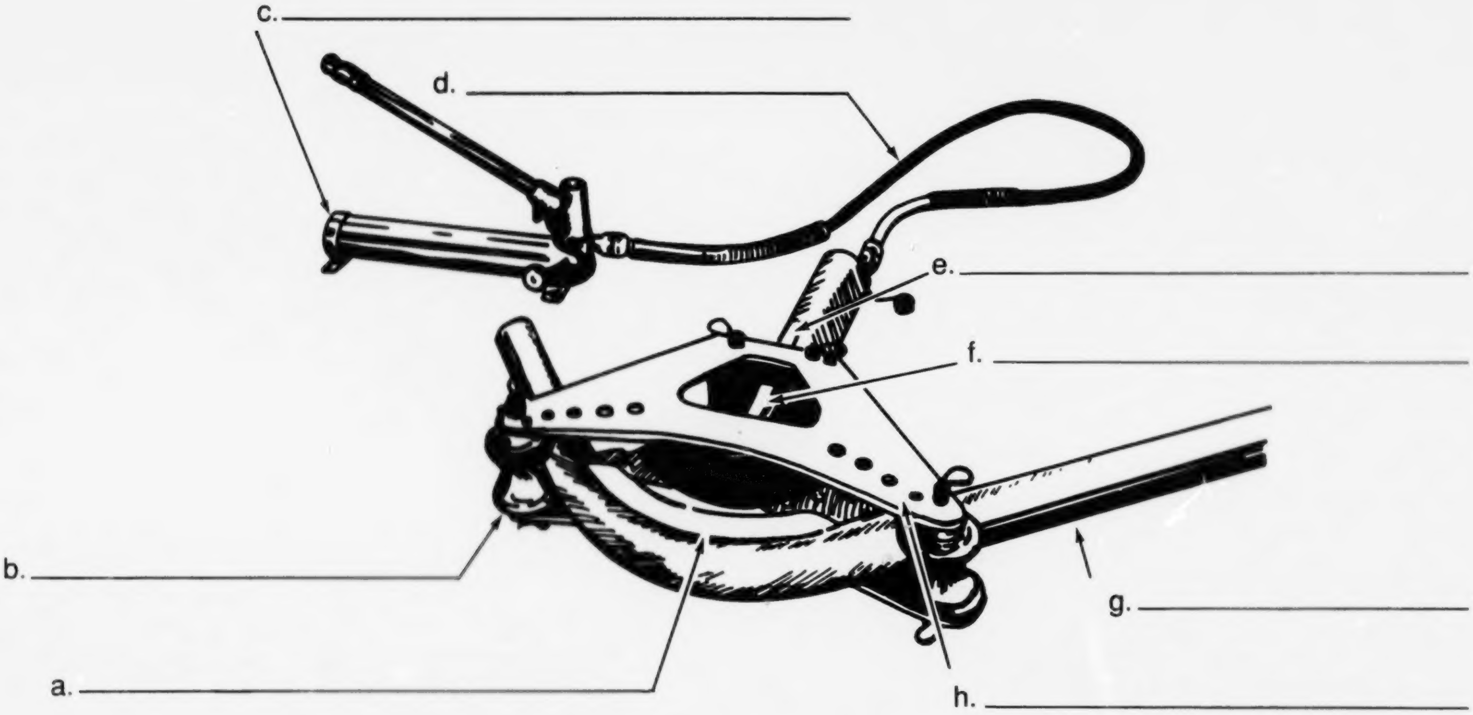
Hydraulic Knockout Set



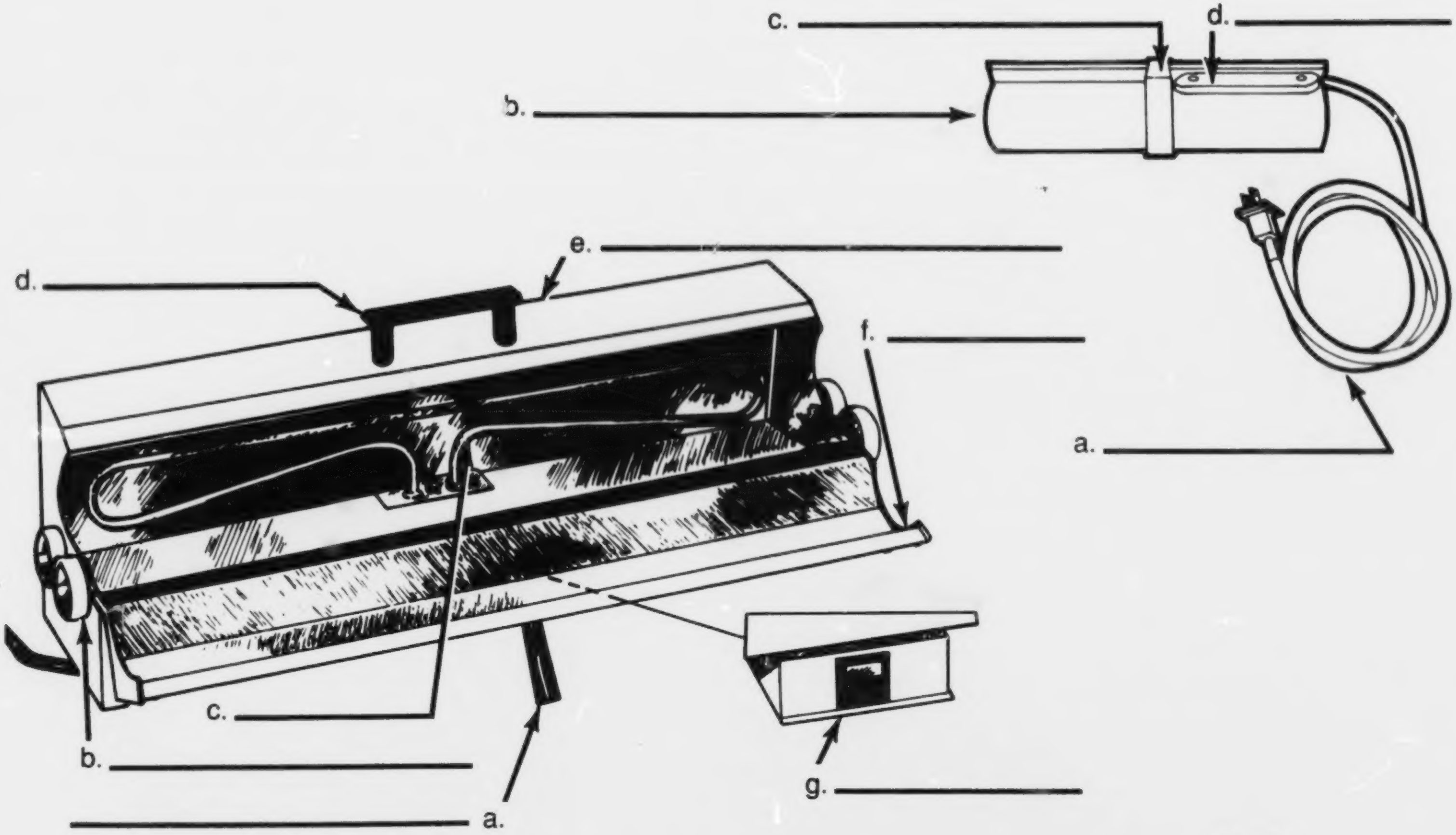
Basic Wiring, Unit 5
Teacher Page 29

TM 1

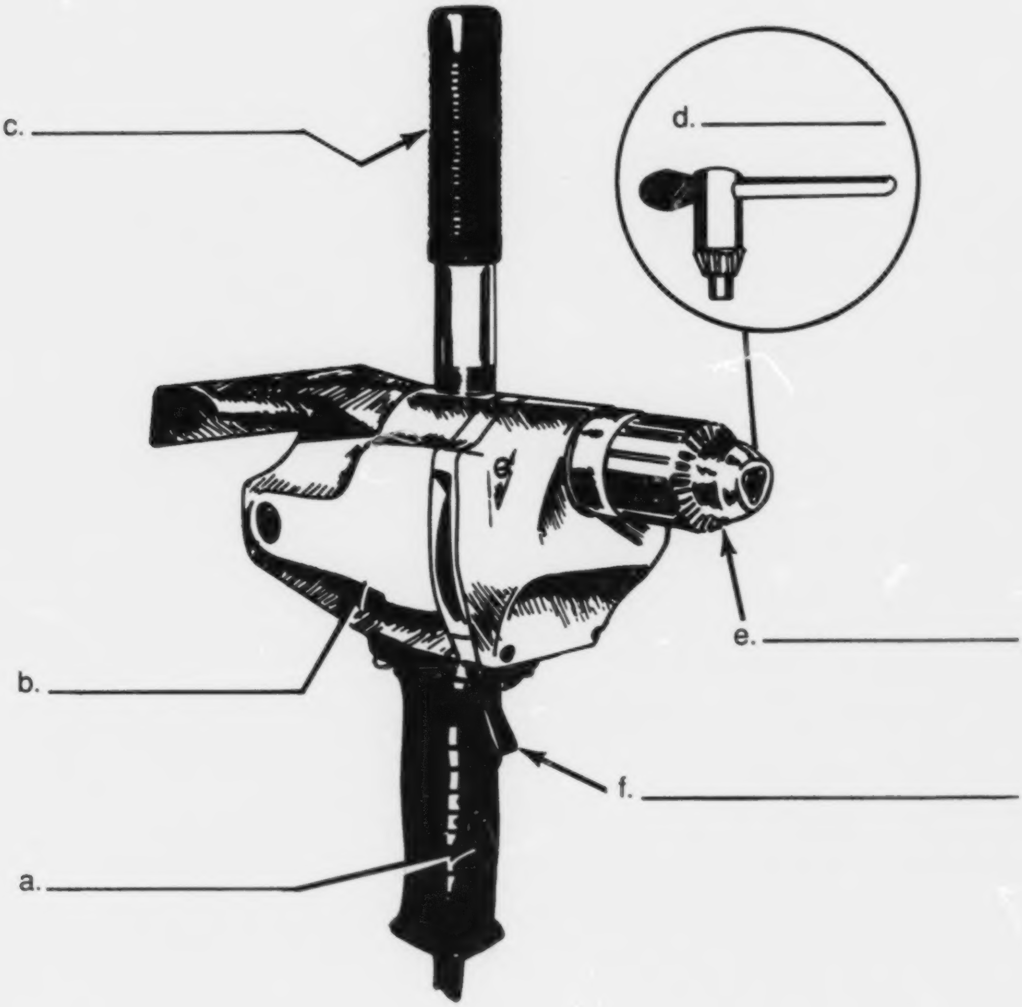
Hydraulic Pipe Bender



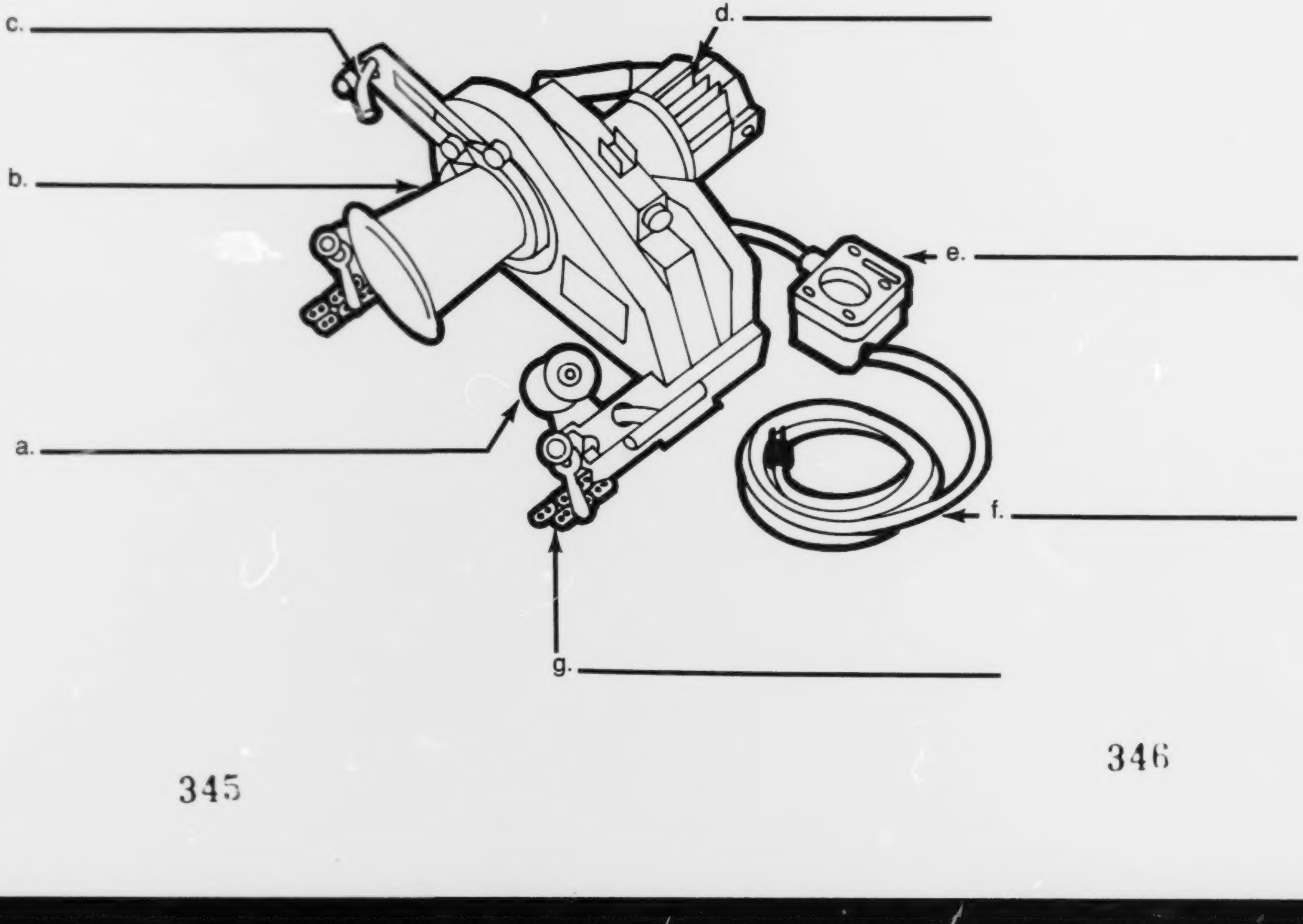
PVC Heater and Blanket


c.
d.
b.
a.
e.
d.
f.
c.
b.
a.
g.

Power Drill



Power Cable Puller



Portable and Table Band Saws

Portable Band Saw

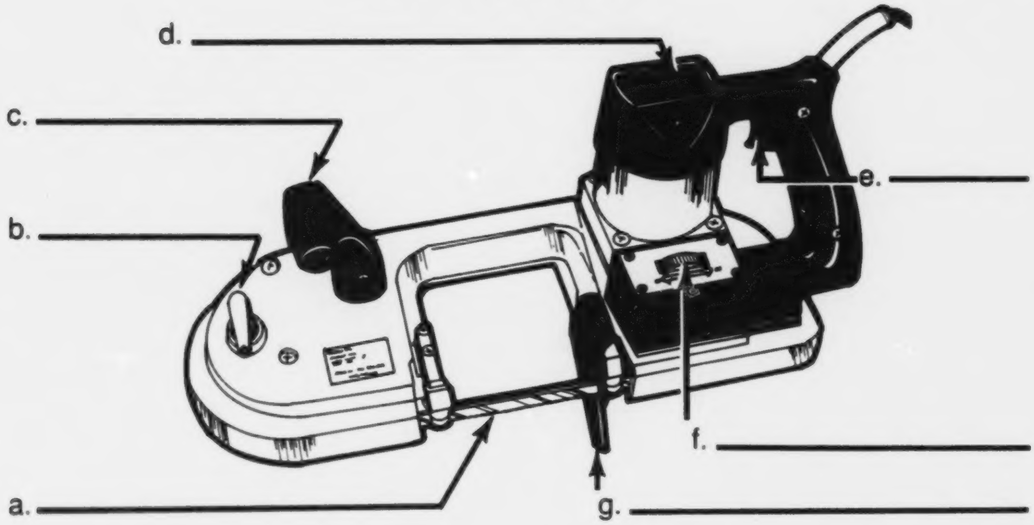
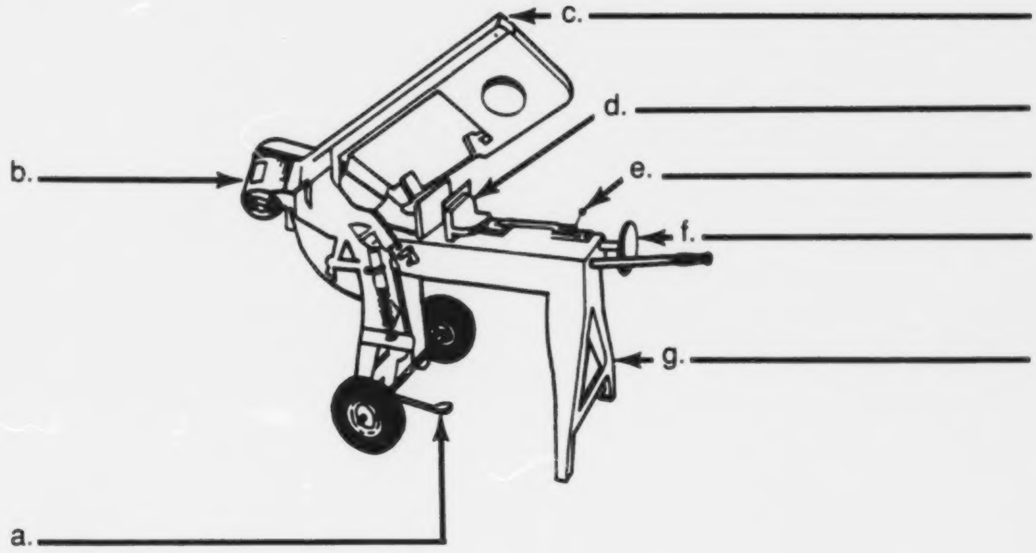
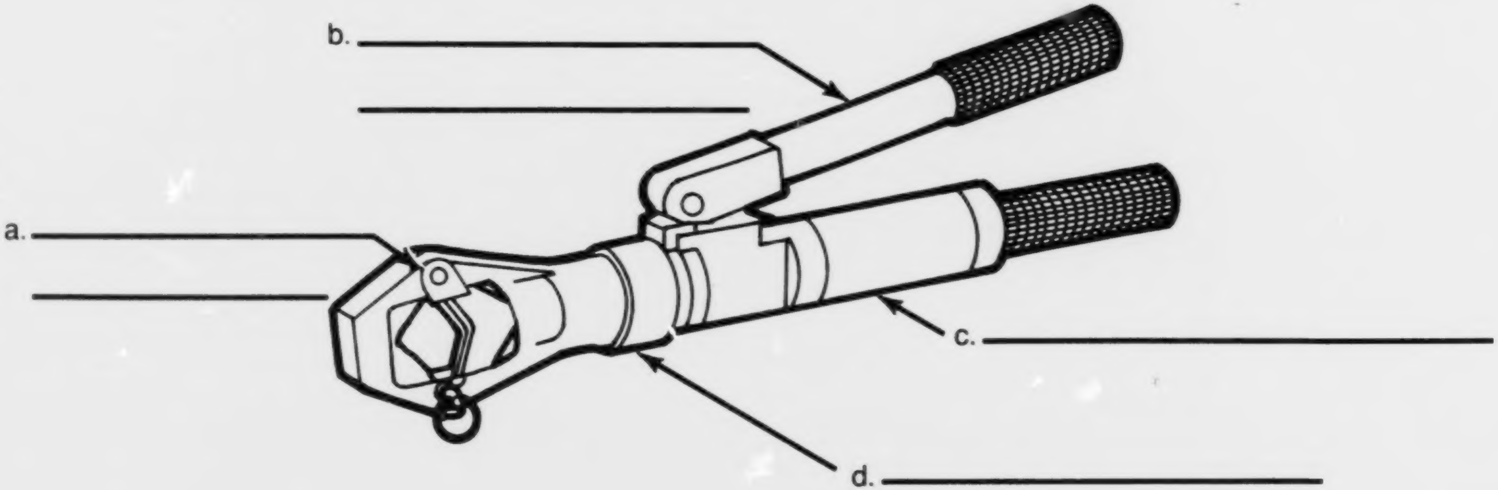


Table Band Saw



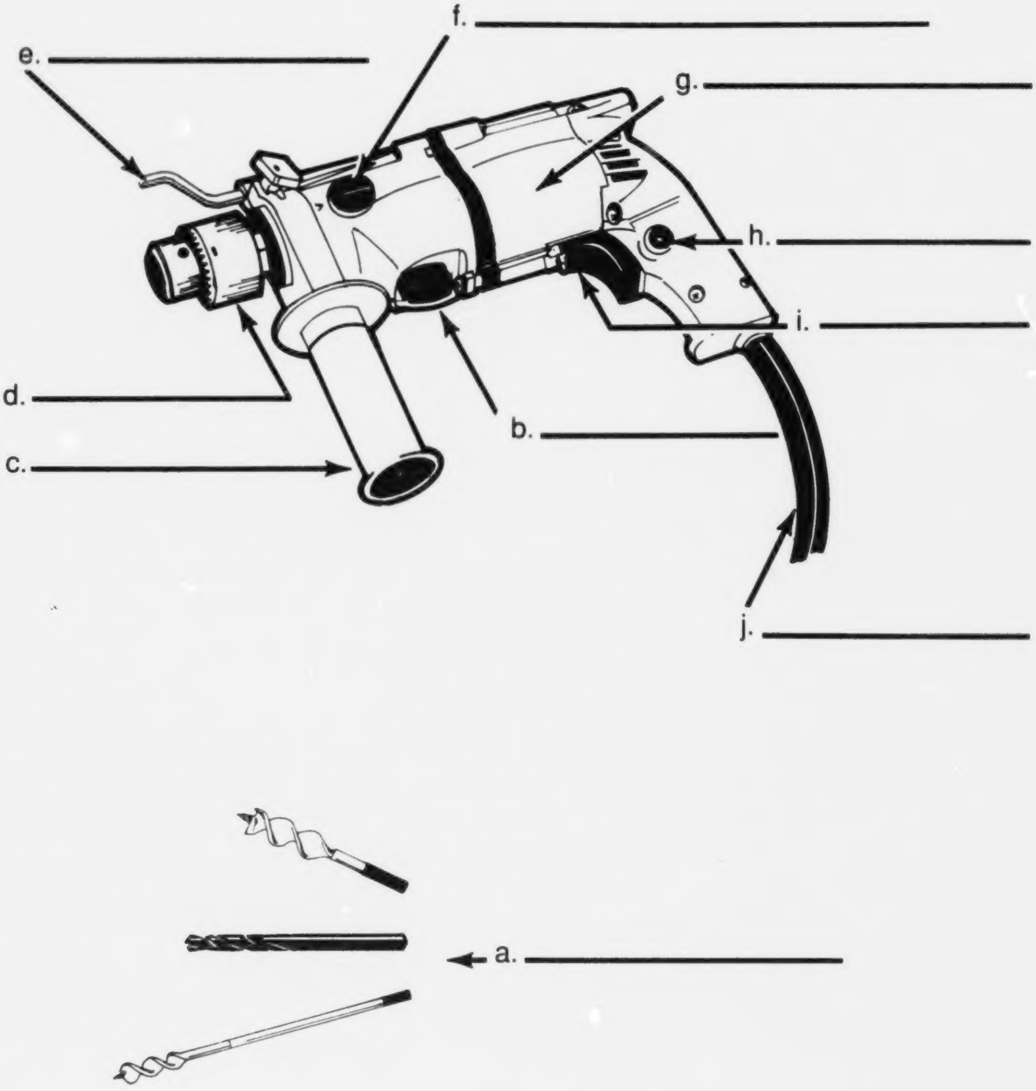
Dieless Hydraulic Crimper



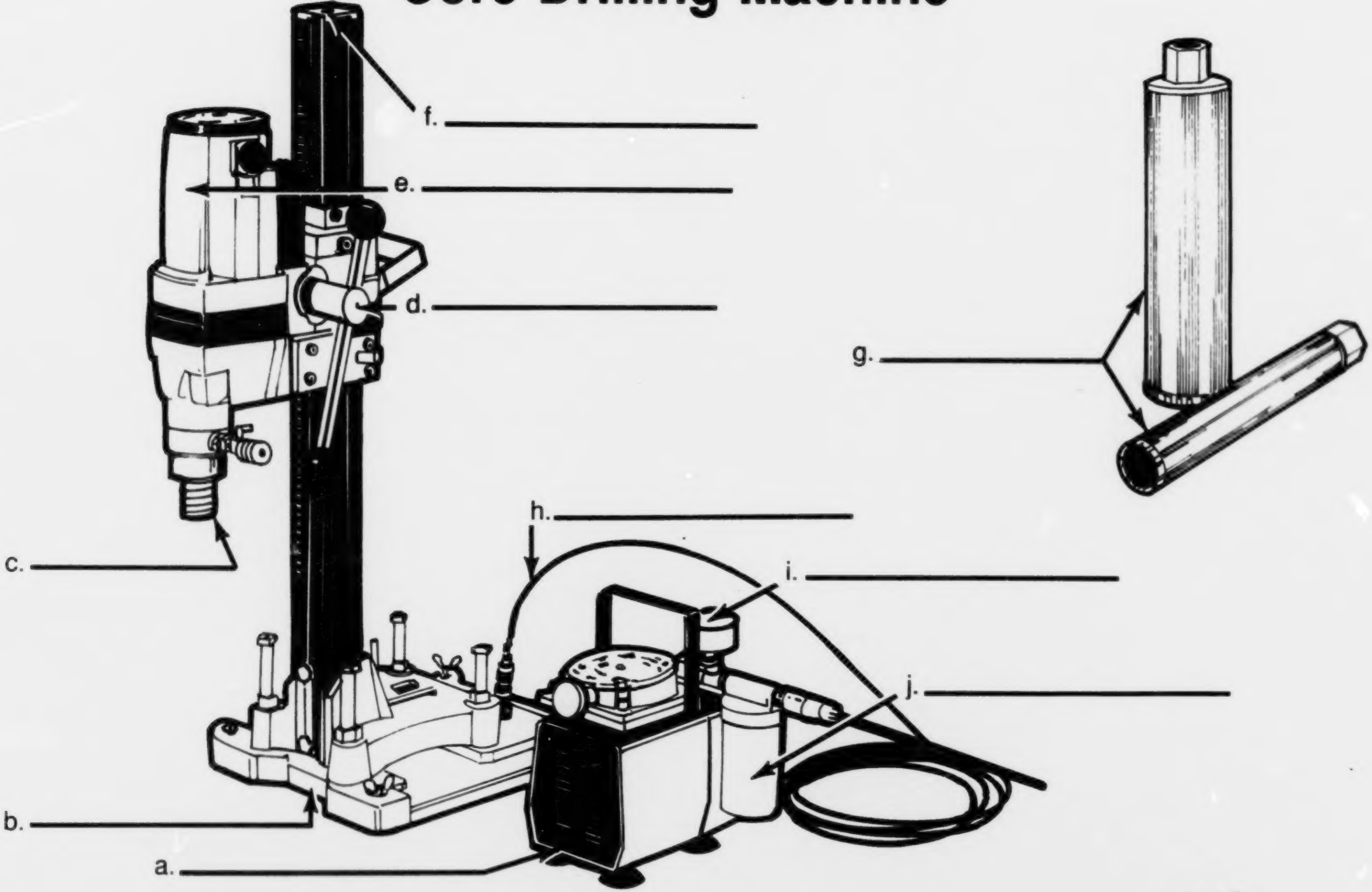
Basic Wiring, Unit 5
Teacher Page 41

TM 7

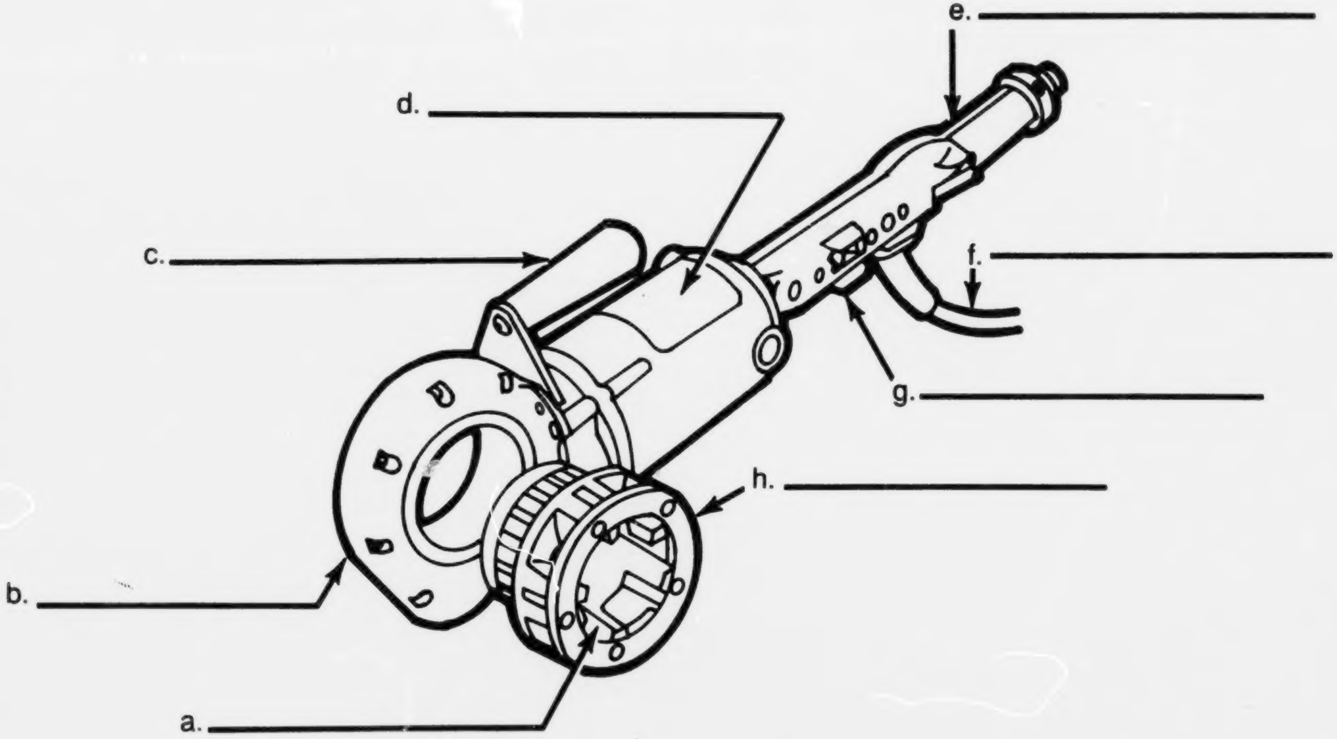
Hammer Drill


f.
e.
g.
h.
i.
d.
b.
c.
j.
a.

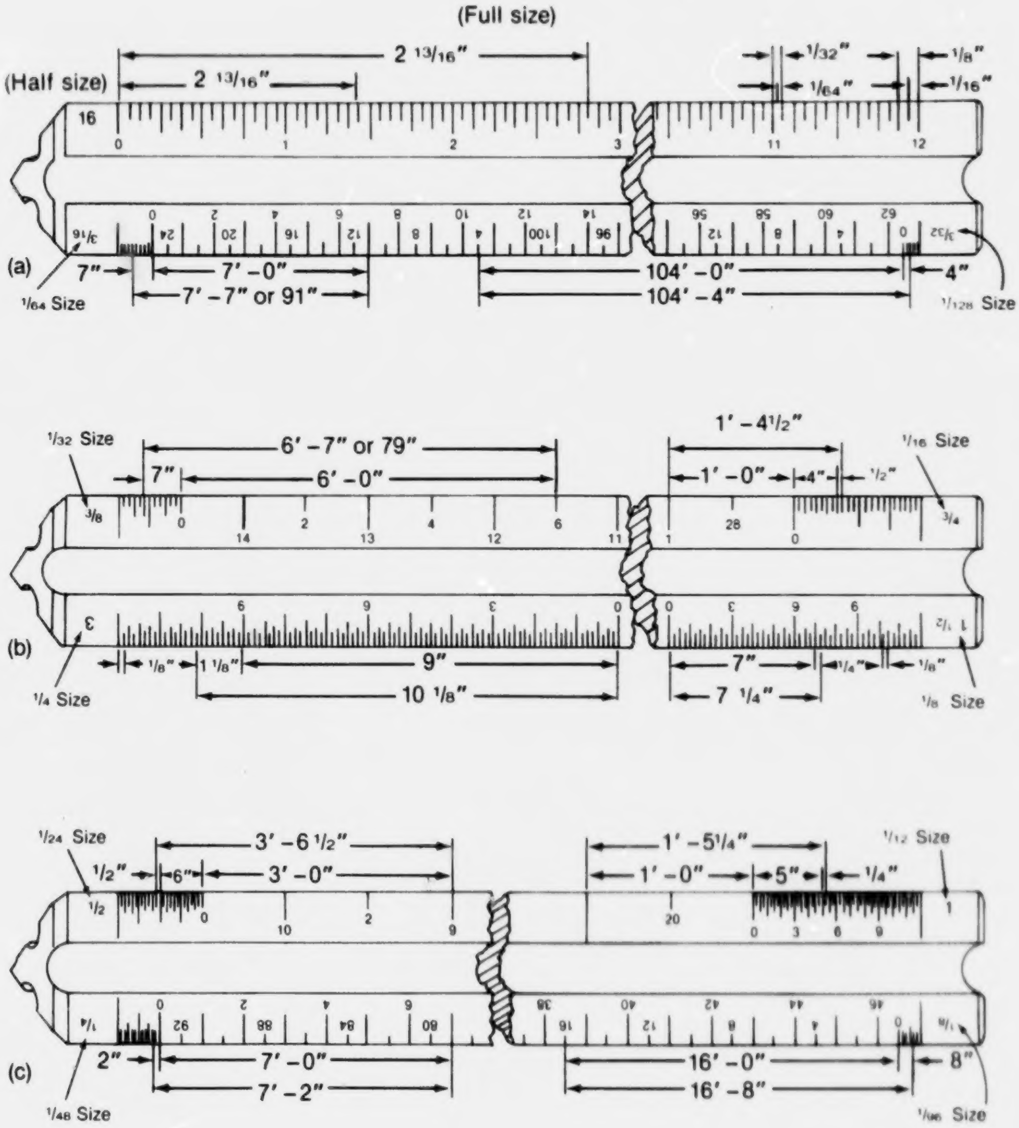
Core Drilling Machine


f. ____
e. ____
d. ____
g. ____
h. ____
c. ____
i. ____
j. ____
b. ____
a. ____

Portable Power Threader

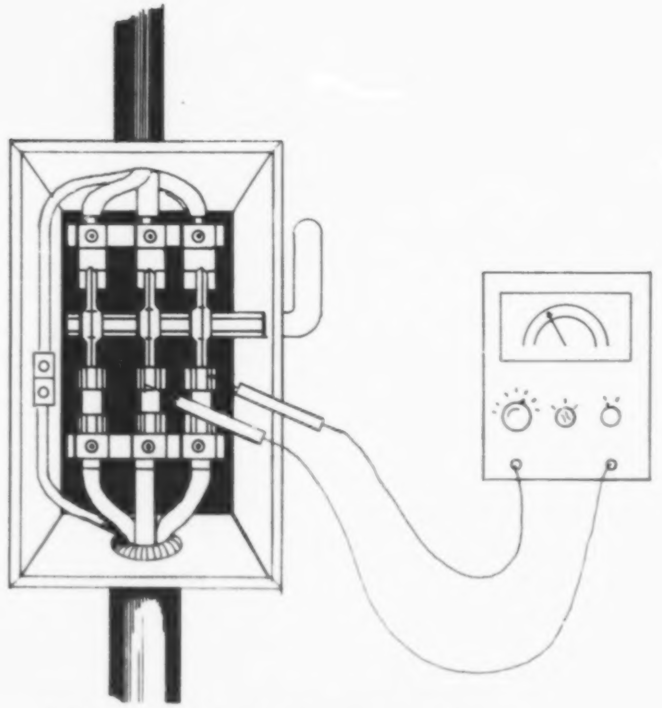


Architect's Scale

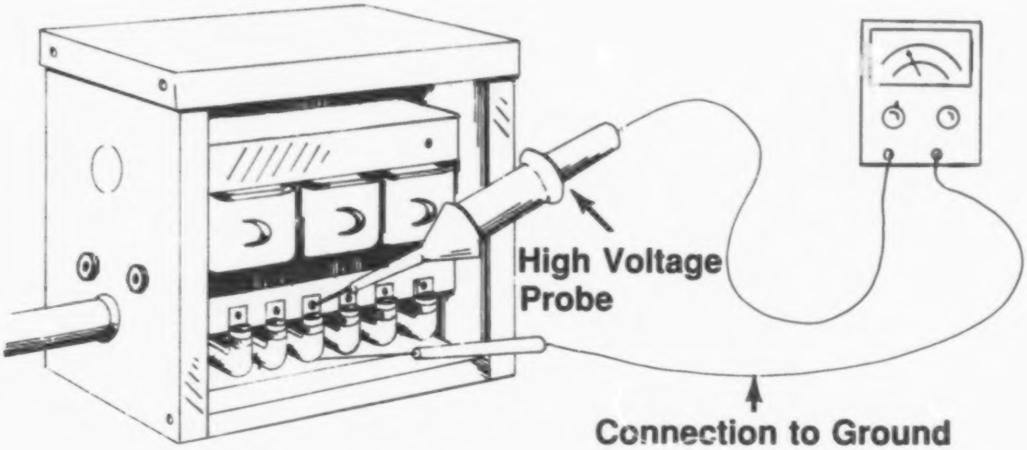

(Full size)
(Half size)
2 13/16"
2 13/16"
1/32"
1/8"
1/64"
1/16"
16
0
1
2
3
11
12
3/16
3/32
(a)
7"
7' -0"
104' -0"
4"
1/64 Size
7' -7" or 91"
104' -4"
1/128 Size
1/32 Size
6' -7" or 79"
1' -4 1/2"
1/16 Size
7"
6' -0"
1' -0"
4"
1/2"
3/8
3/4
3
1 1/2
(b)
1/8"
1 1/8"
9"
7"
1/4"
1/8"
1/4 Size
10 1/8"
7 1/4"
1/8 Size
1/24 Size
3' -6 1/2"
1' -5 1/4"
1/12 Size
1/2"
6"
3' -0"
1' -0"
5"
1/4"
1/2
1
1/4
1/8
(c)
2"
7' -0"
16' -0"
8"
7' -2"
16' -8"
1/48 Size
1/96 Size

This is how the architect's scale should look.

Voltage Measurement Techniques

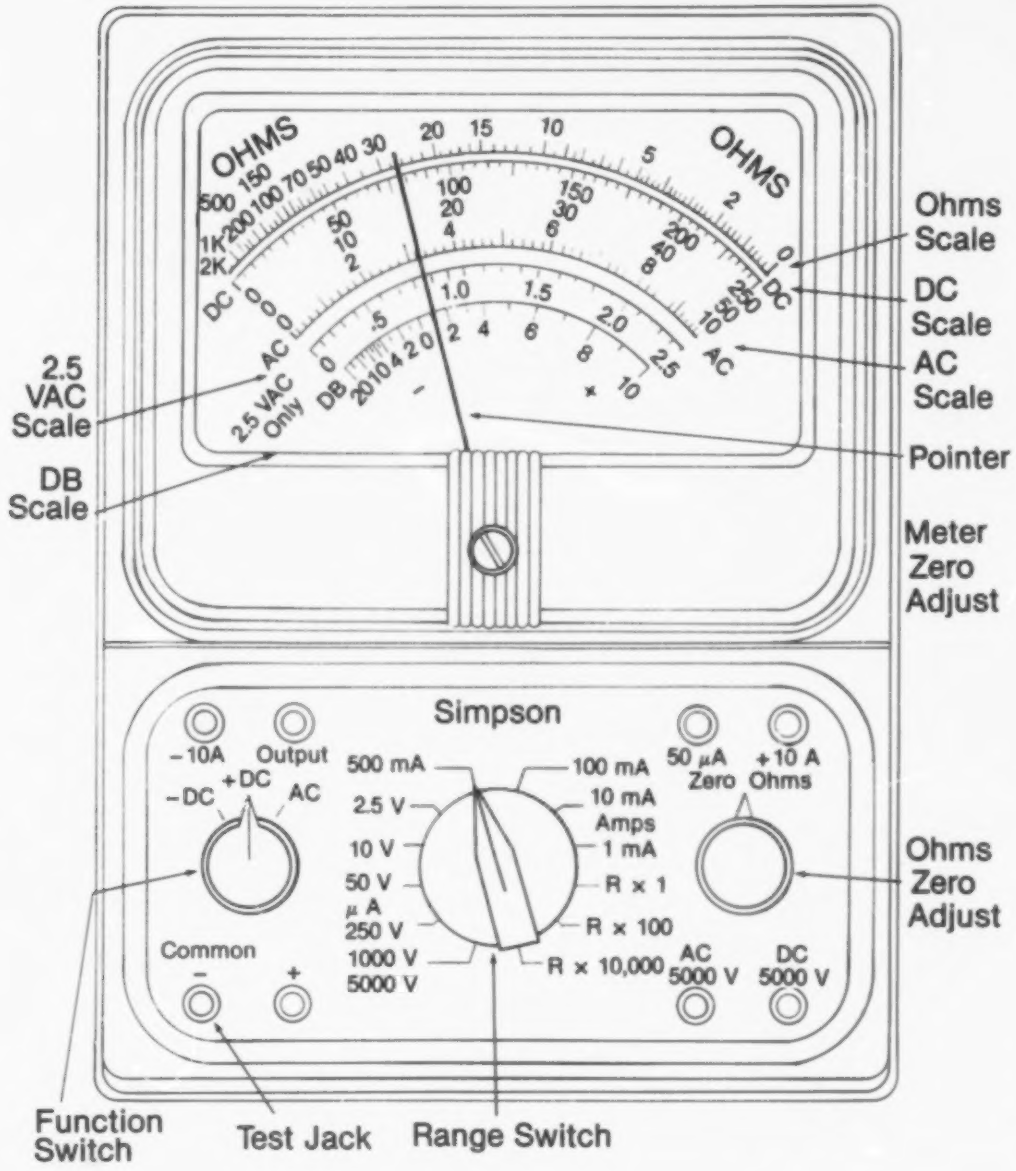


Direct Parallel Measurement

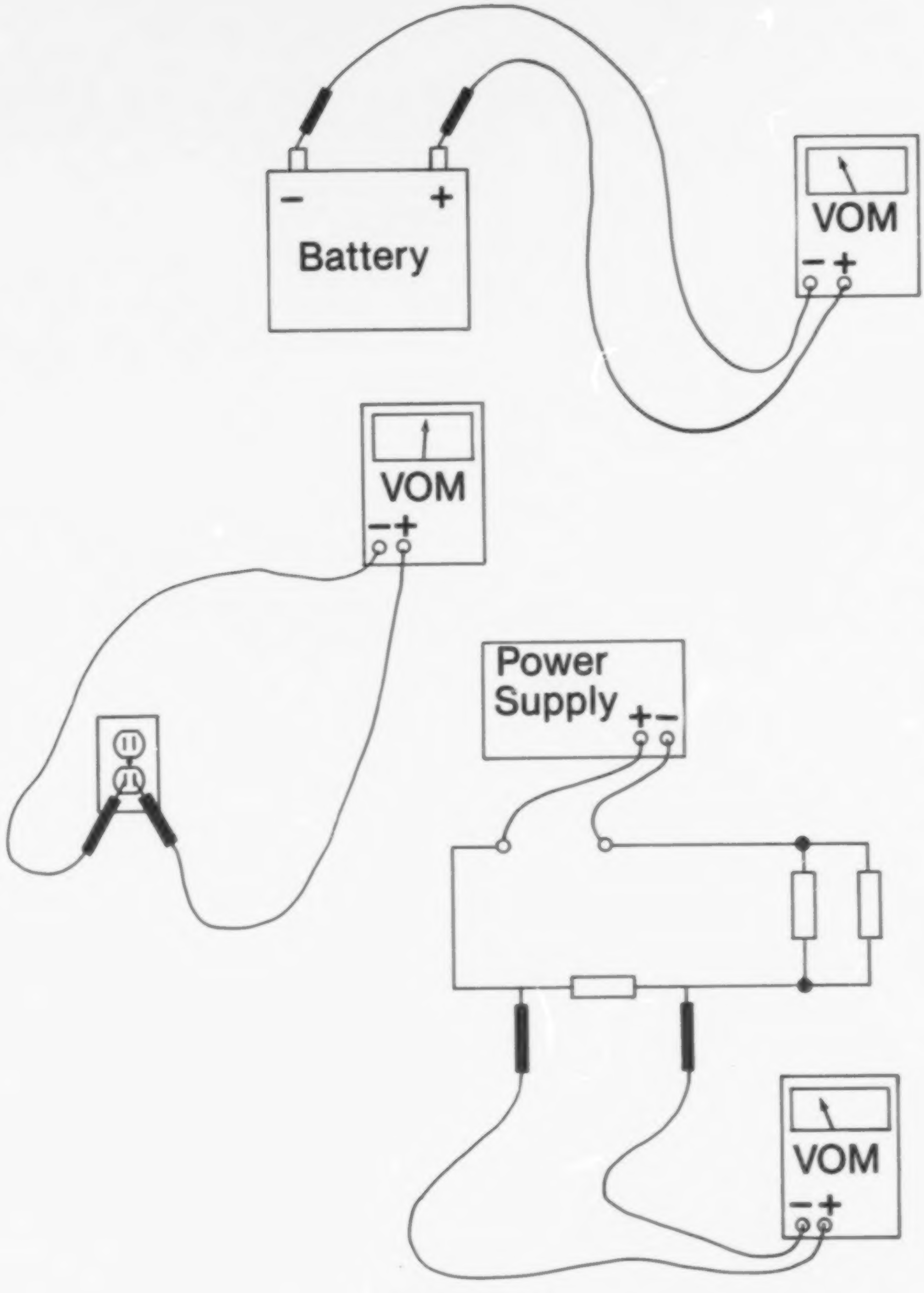

High Voltage Probe
Connection to Ground

High Voltage Probe

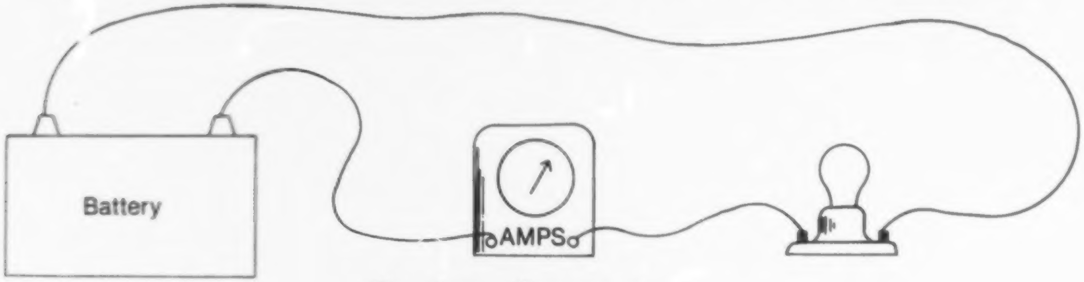
Permanent Magnet Moving Coil Multimeter


OHMS
OHMS
Simpson
−10A
Output
−DC
+DC
AC
500 mA
2.5 V
10 V
50 V
μ A
250 V
1000 V
5000 V
100 mA
10 mA
Amps
1 mA
R × 1
R × 100
R × 10,000
50 μA
Zero
+10 A
Ohms
Common
−
+
AC
5000 V
DC
5000 V
2.5 VAC Only
DB
Ohms Scale
DC Scale
AC Scale
Pointer
Meter Zero Adjust
Ohms Zero Adjust
2.5 VAC Scale
DB Scale
Function Switch
Test Jack
Range Switch

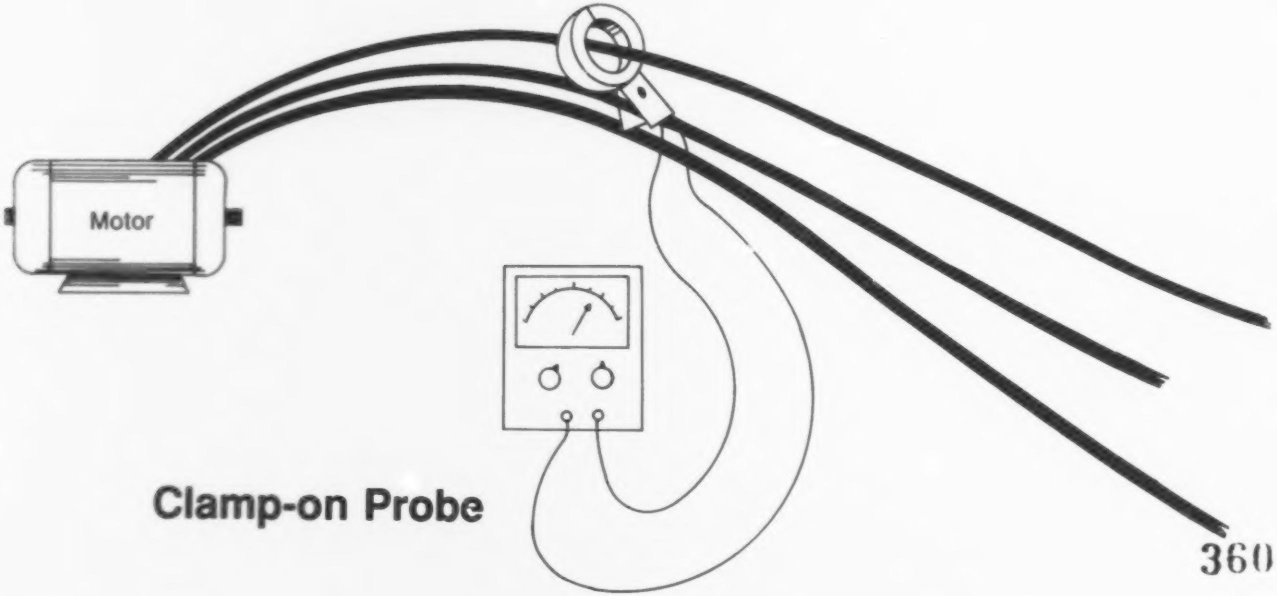
Correct Voltage Measurements


−
+
Battery
VOM
− +
VOM
− +
Power
Supply
+ −
VOM
− +

Amperage Measurement Techniques


Battery
AMPS

Series Ammeter

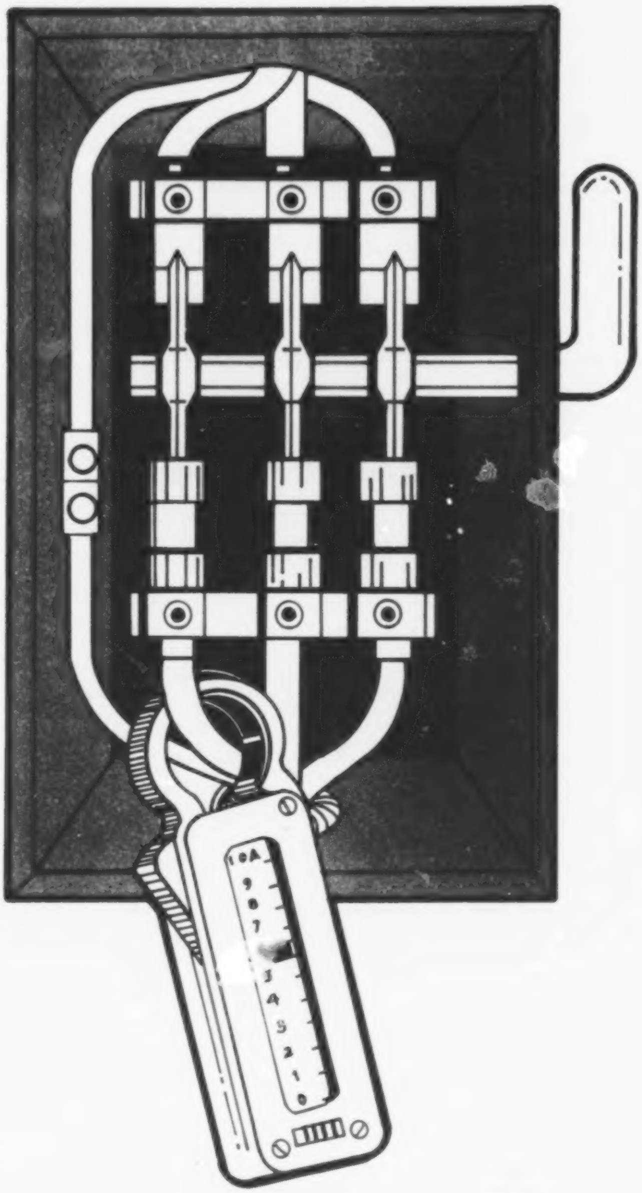


Clamp-on Probe

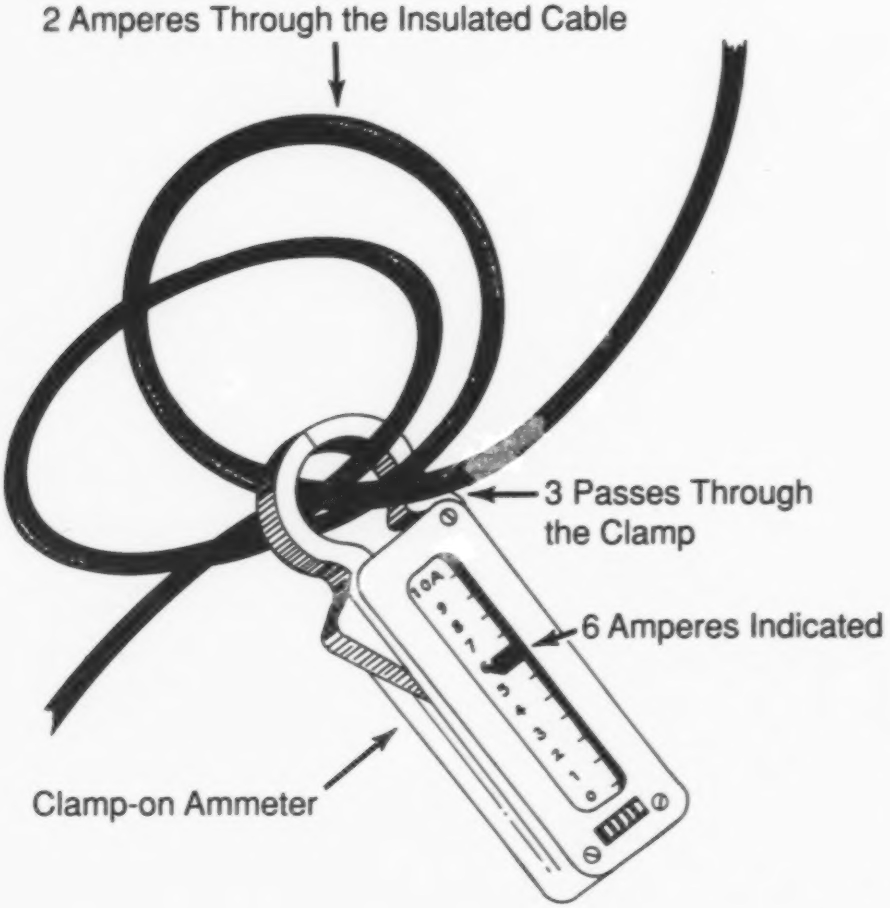
TM 15

Clamp-on Ammeter

Measuring Current in a Safety Switch Using a Clamp-on Ammeter



Determining Current of a Multiple Loop Using a Clamp-on Ammeter


2 Amperes Through the Insulated Cable
3 Passes Through the Clamp
10A
9
8
7
5
4
3
2
1
0
6 Amperes Indicated
Clamp-on Ammeter

Note: The loops should be wrapped tightly together with electrical tape at the point of measurement.

Specialty Tools and Equipment
Unit 5

Information Sheet

1. **Terms and definitions**

   a. **Accuracy** — How near the instrument reading is to the actual value

   b. **Amperage** — Electricity; electrical current flow; electron flow; must be measured at a point within a circuit

   c. **Bender** — Tool used to make various angles or bends in conduit

   d. **Calibration** — Technique of testing and adjusting an instrument by referring it to another instrument or device of known accuracy and precision

   e. **Chuck** — Portion of drill that holds the bit

   f. **Cross handle** (T-handle) — Handle set across a power tool to prevent the tool from turning

   g. **Cutter** — Hardened steel device used to cut holes in metal boxes

   h. **Die** — Component that backs up cutter on opposite side of metal box

   i. **Error** — How far a measurement is from the actual value

   j. **Ground** — Electrical point or any good conductor that is connected to a common chassis with zero relative voltage; usually conductors are connected to the earth

   k. **Hydraulic** — Using pressurized fluid to accomplish work

   l. **Hydraulic oil** — Specially formulated oil for hydraulic pumps

      Note: No oil or fluid should ever be substituted for hydraulic oil.

   m. **Knockout punch** — Device used to make openings for conduit in metal enclosures

   n. **Multimeter** — Instrument capable of measuring a "multiple" of values

      Examples: Amperage, voltage, and resistance with several measurement ranges

   o. **Parallax correction** — Viewing analog VOM from directly above the needle to avoid the possibility of wrong readings due to depth perception

Information Sheet

p. **Pinch point** — Any opening that may close and bind a finger or hand

q. **Polyvinylchloride (PVC) conduit** — Plastic pipe

r. **Precision** — Instrument consistency

Example: A "precision meter" might not be accurate. It may measure 1 volt at 1.20 volts, but each time the reading will be precisely 1.20, not 1.21 or 1.10. A calibration adjustment could correct the meter reading to 1.00 at 1 volt and would then precisely repeat a 1.00 reading.

s. **Ram** — Device used to transfer hydraulic pressure to a mechanical device

t. **Resistance** — Opposition to electrical current flow; measured in units of ohms; must be measured from one point to another

u. **Resolution** — How well an instrument will indicate a small change in the measured value

Example: A precise, accurate, and sensitive meter may respond by moving the meter hand 1/16" for a small change in measured amperage. If the scale is marked only one division per inch, the meter would still lack "resolution" since the operation could not determine what amount of current change this represents.

v. **Voltage** — Electromotive force (emf) that drives electricity through conductors; must be measured across or referenced to a second point.

Example: Ground

2. **Typical power equipment**

a. Hydraulic knockout set

b. Hydraulic pipe bender

c. PVC heaters and blankets

d. Power drill

e. Power cable puller

f. Portable and table band saws

g. Dieless hydraulic crimper

Information Sheet

- h. Hammer drill
- i. Core drilling machine
- j. Portable power threader

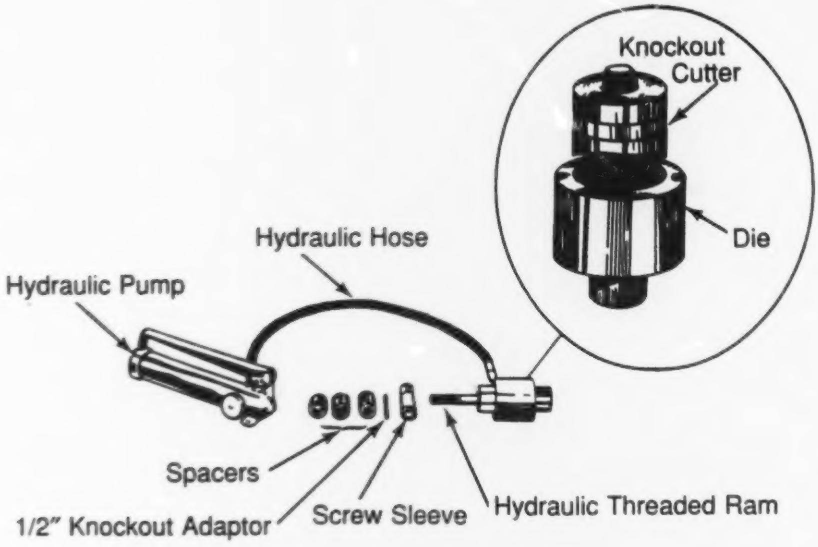
3. **General safety rules for using power equipment**
   - a. Always follow manufacturer's operating instructions.
   - b. Never place hands in a pinch point.
   - c. Use eye protection.
   - d. Wear gloves when working with hot equipment or materials.
   - e. Always secure loose clothing such as shirt sleeves and shirttails.
   - f. Tie back long hair and do not wear dangling jewelry.
   - g. Never exceed rated capacity of equipment.
   - h. Never remove protective guards from equipment.
   - i. Be prepared for the unexpected.

     Note: Make sure that your footing and body position are such that you will not lose balance in the event that the unexpected happens.

Information Sheet

4. **Parts of a hydraulic knockout set** (Figure 1)

Figure 1


Knockout Cutter
Die
Hydraulic Hose
Hydraulic Pump
Spacers
1/2" Knockout Adaptor
Screw Sleeve
Hydraulic Threaded Ram

5. **Safety rules for using hydraulic knockout sets**

   a. Never substitute brake fluid for hydraulic oil.

   b. Never disconnect the hose when it is under pressure.

   c. Do not use near live electrical parts.

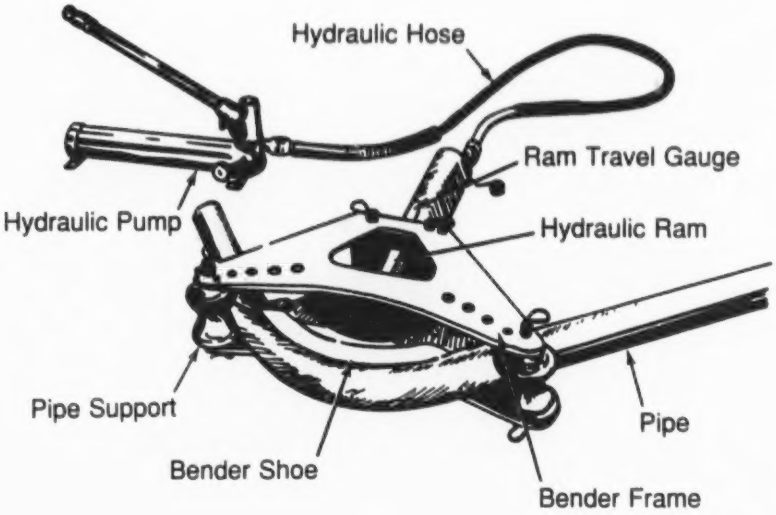
   d. Never force the pump handle.

   e. Always wear eye protection.

Information Sheet

6. **Parts of a hydraulic pipe bender** (Figure 2)

Figure 2


Hydraulic Hose
Ram Travel Gauge
Hydraulic Pump
Hydraulic Ram
Pipe Support
Pipe
Bender Shoe
Bender Frame

7. **Safety rules for using hydraulic pipe benders**

   a. Never substitute brake fluid for hydraulic oil.

   b. Never disconnect the hose when it is under pressure.

   c. Never place hands near ram or shoe while bending.

   d. Always use proper size conduit shoe and support.

   e. Be sure that floor area is clear for pipe movement.

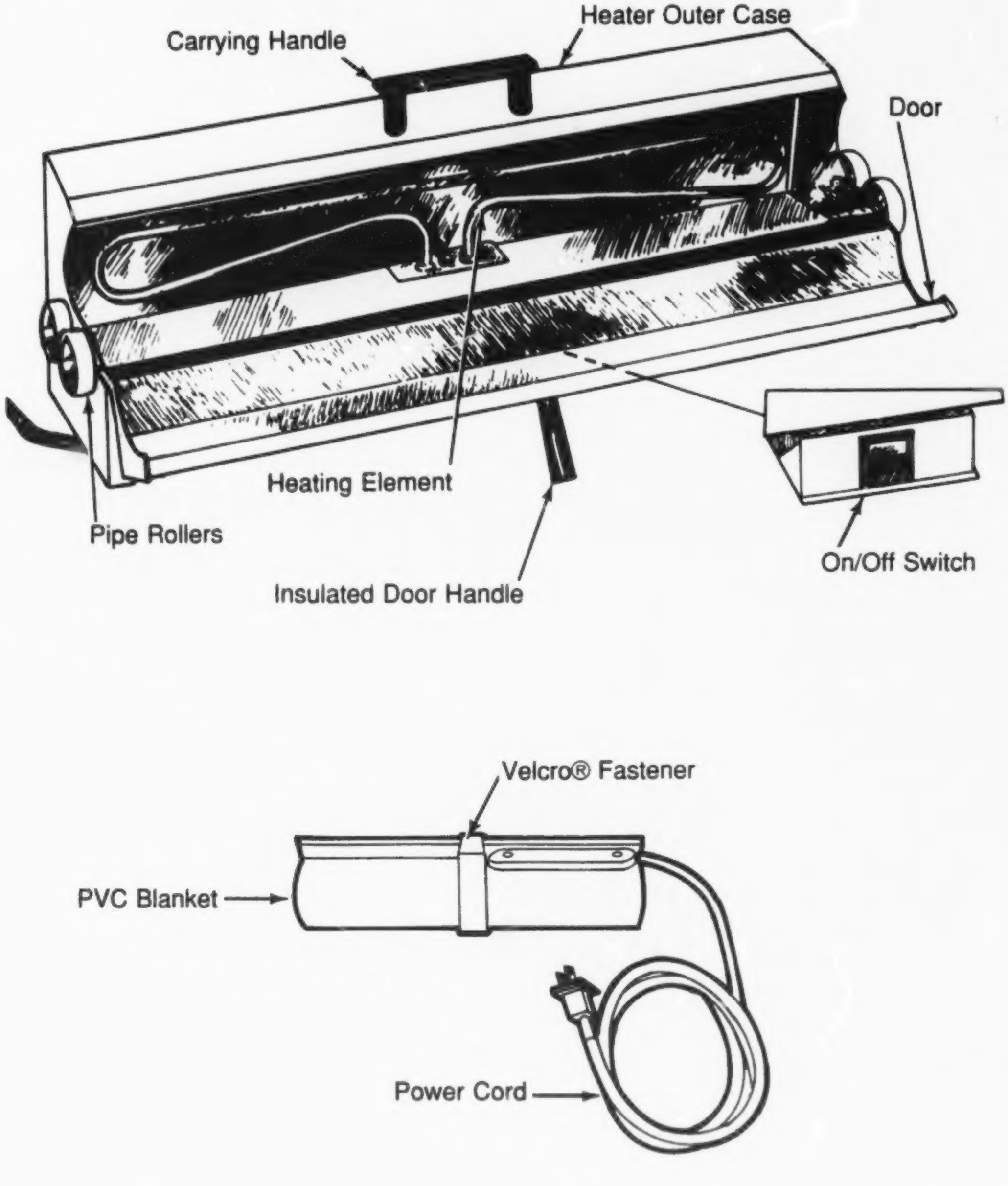
   f. Lift heavy bender parts correctly.

      Note: Some bender parts weigh more than 50 pounds and require more than one person to assemble or move.

   g. Make sure that the shoe, follow bar, saddle, pipe support, and other accessories are appropriate for the size and type conduit being bent.

8. **Parts of PVC heaters and blankets** (Figure 3)

Figure 3


Heater Outer Case
Carrying Handle
Door
Heating Element
Pipe Rollers
Insulated Door Handle
On/Off Switch
Velcro® Fastener
PVC Blanket
Power Cord

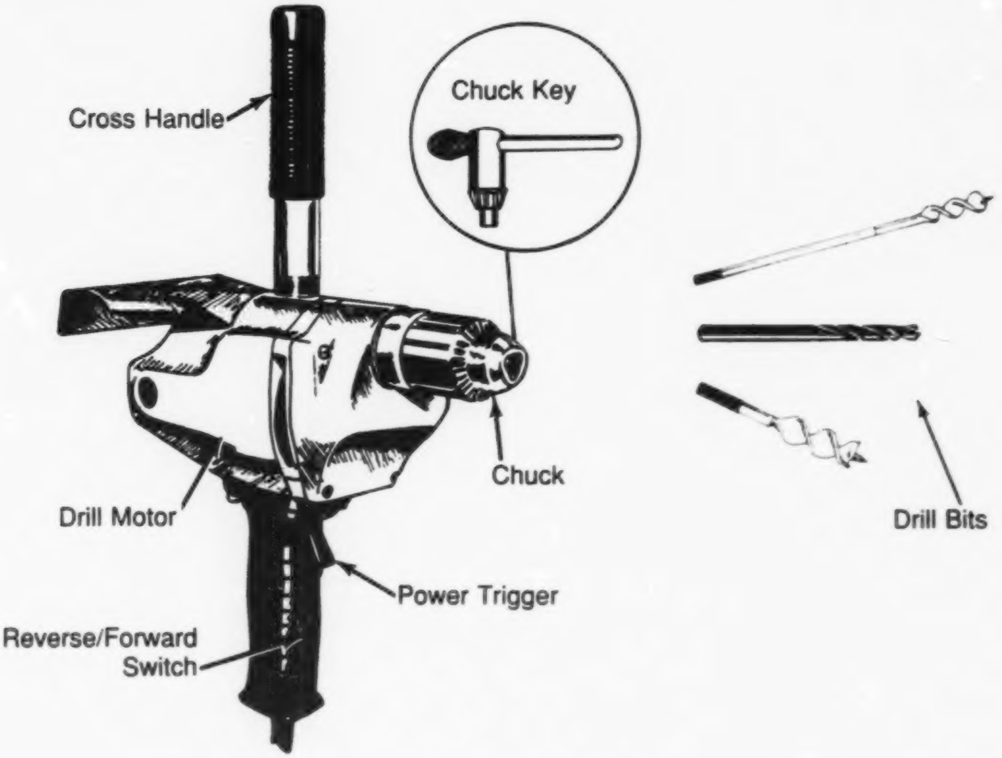
Information Sheet

9. Safety rules for using PVC heaters and blankets

- a. Never use in wet locations.
- b. Always wear gloves when handling hot heater or pipe.
- c. Use only with PVC conduit.
- d. Use only for specified type and size of PVC conduit.
- e. Always turn heater or blanket off when not in use.
- f. Use only in a well-ventilated, noncluttered area.
- g. Never leave unattended while turned on.
- h. Keep hands and other body parts from direct contact with hot surfaces.

10. Parts of a power drill (Figure 4)

Figure 4


Chuck Key
Cross Handle
Chuck
Drill Motor
Drill Bits
Power Trigger
Reverse/Forward Switch

Information Sheet

11. **Safety rules for using power drills**

    a. Check area to be drilled for hidden wires or pipes.

    b. Hold drill securely with both hands.

    c. Place small objects to be drilled in a vise.

    d. Always hold the drill steady and perpendicular to the work to prevent the bit from breaking or binding.

    e. Always use a T-handle when drilling to allow you to secure the hammer drill when it encounters especially hard surfaces.

    f. **Never** lock the trigger in the "on" position.

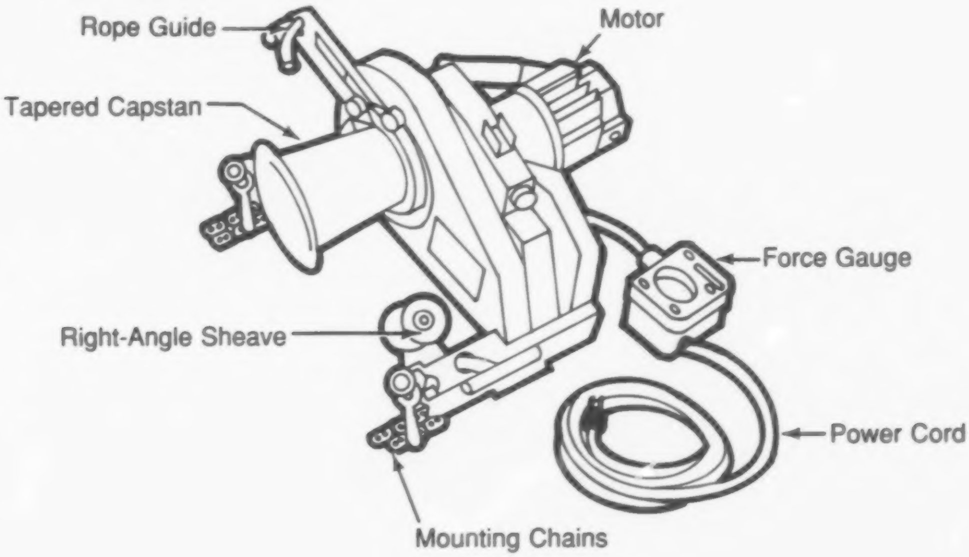
    g. Never drill while off balance.

    Note: Make sure that your footing and body position are such that you will not lose balance in the event that the unexpected happens.

    h. Always wear eye protection.

12. **Parts of a power cable puller** (Figure 5)

Figure 5


Rope Guide
Motor
Tapered Capstan
Force Gauge
Right-Angle Sheave
Power Cord
Mounting Chains

Information Sheet

13. **Safety rules for using a power cable puller**

    a. Ensure that all cable pulling systems, accessories, and rope have the proper load for the pull.

    b. Mount and secure pulling unit according to manufacturer's instructions.

    Note: These units create a tremendous amount of force and may cause injury if not mounted and secured properly.

    c. Stand out of direct line of force.

    Note: A broken rope or cable can whiplash with lethal force.

    d. Monitor pull of force gauge, and never exceed maximum force.

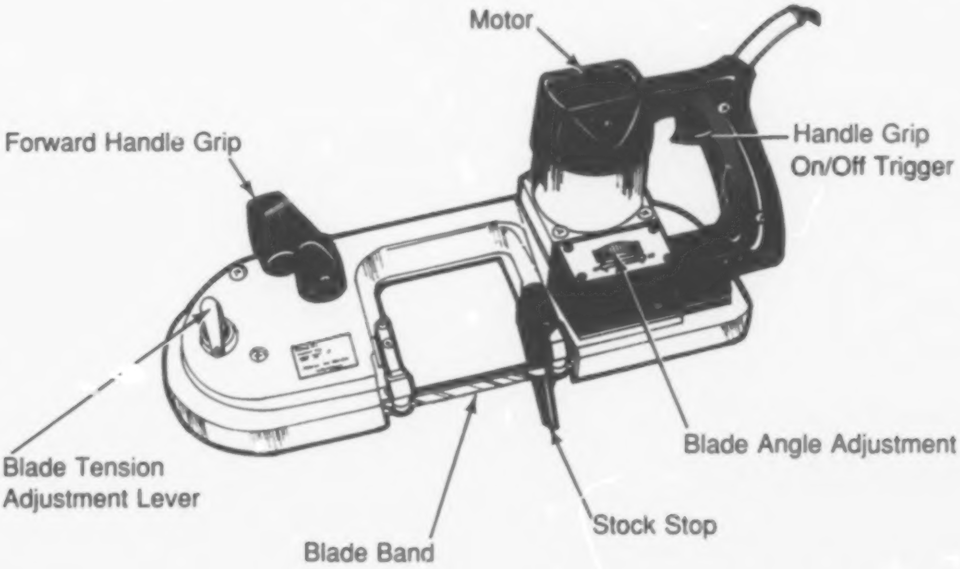
    Note: Most of today's power cable pullers are equipped with an audible alarm high force warning and a circuit breaker shut off at maximum force.

    e. Always wear eye protection.

14. **Parts of portable and table band saws** (Figures 6 and 7)

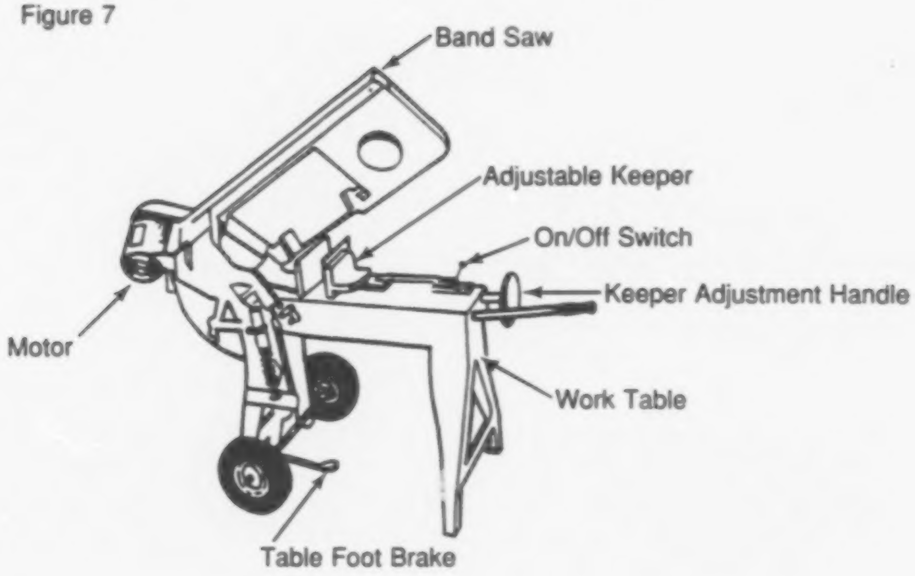
    a. Portable band saw

    Figure 6


Motor
Forward Handle Grip
Handle Grip On/Off Trigger
Blade Tension Adjustment Lever
Blade Angle Adjustment
Stock Stop
Blade Band

b. Table band saw

Figure 7


Band Saw
Adjustable Keeper
On/Off Switch
Keeper Adjustment Handle
Motor
Work Table
Table Foot Brake

15. Safety rules for using portable and table bandsaws

a. Secure object to be cut in a vise or other stable rest.

b. Check the blade for missing teeth that could result in the blade binding or breaking.

c. Do not remove or alter safety guards.

d. Keep hands clear of the blade.

e. Never saw while off balance.

Note: Make sure that your footing and body position are such that you will not lose balance in the event that the unexpected happens.

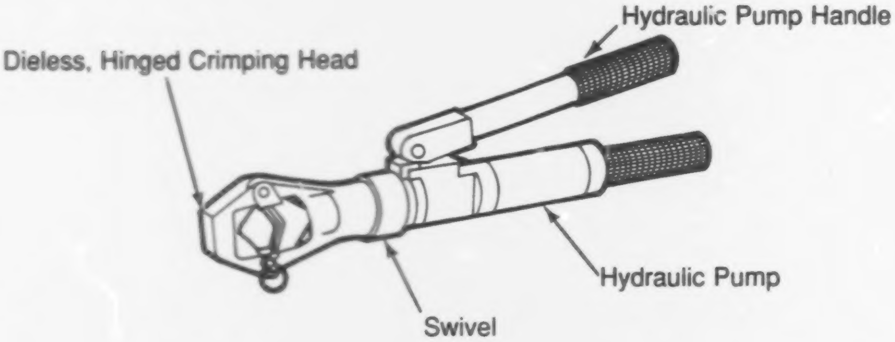
f. Always wear eye protection.

Information Sheet

16. **Parts of a dieless hydraulic crimper** (Figure 8)

Note: This model has a hinged crimping head for easy splice connector loading and unloading. The crimper swivel head also rotates 180 degrees for flexibility.

Figure 8


Hydraulic Pump Handle
Dieless, Hinged Crimping Head
Hydraulic Pump
Swivel

17. **Safety rules for using hydraulic crimpers**

a. Ensure that die is mounted securely on threading machine.

b. Keep die flooded with cutting oil during operation.

Note: This serves to cool the die as well as to lubricate it.

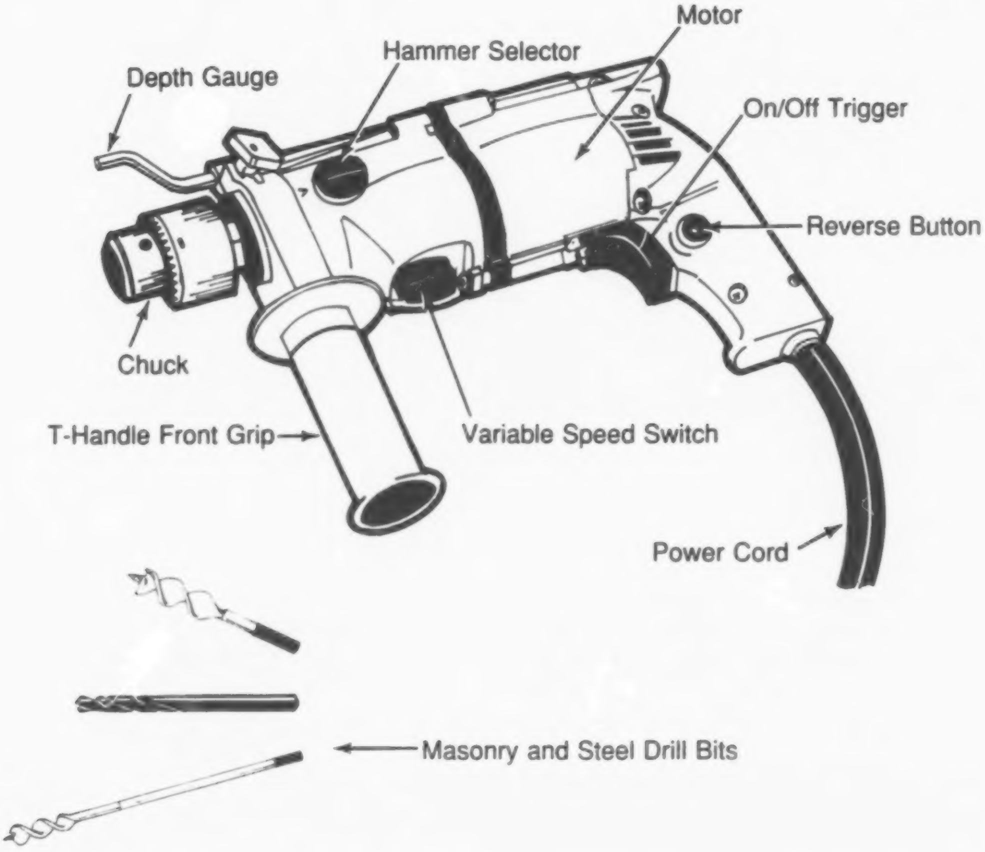
c. Keep hands, clothing, and hair away from rotating parts.

d. Always wear eye protection.

Information Sheet

18. Parts of a hammer drill (Figure 9)

Figure 9


Motor
Hammer Selector
Depth Gauge
On/Off Trigger
Reverse Button
Chuck
T-Handle Front Grip
Variable Speed Switch
Power Cord
Masonry and Steel Drill Bits

19. Safety rules for using a hammer drill

a. Always hold the drill steady and perpendicular to the work to prevent the bit from breaking or binding.

b. Always use a T-handle when drilling to allow you to secure the hammer drill when it encounters especially hard surfaces.

c. **Never** lock the trigger in the "on" position.

Information Sheet

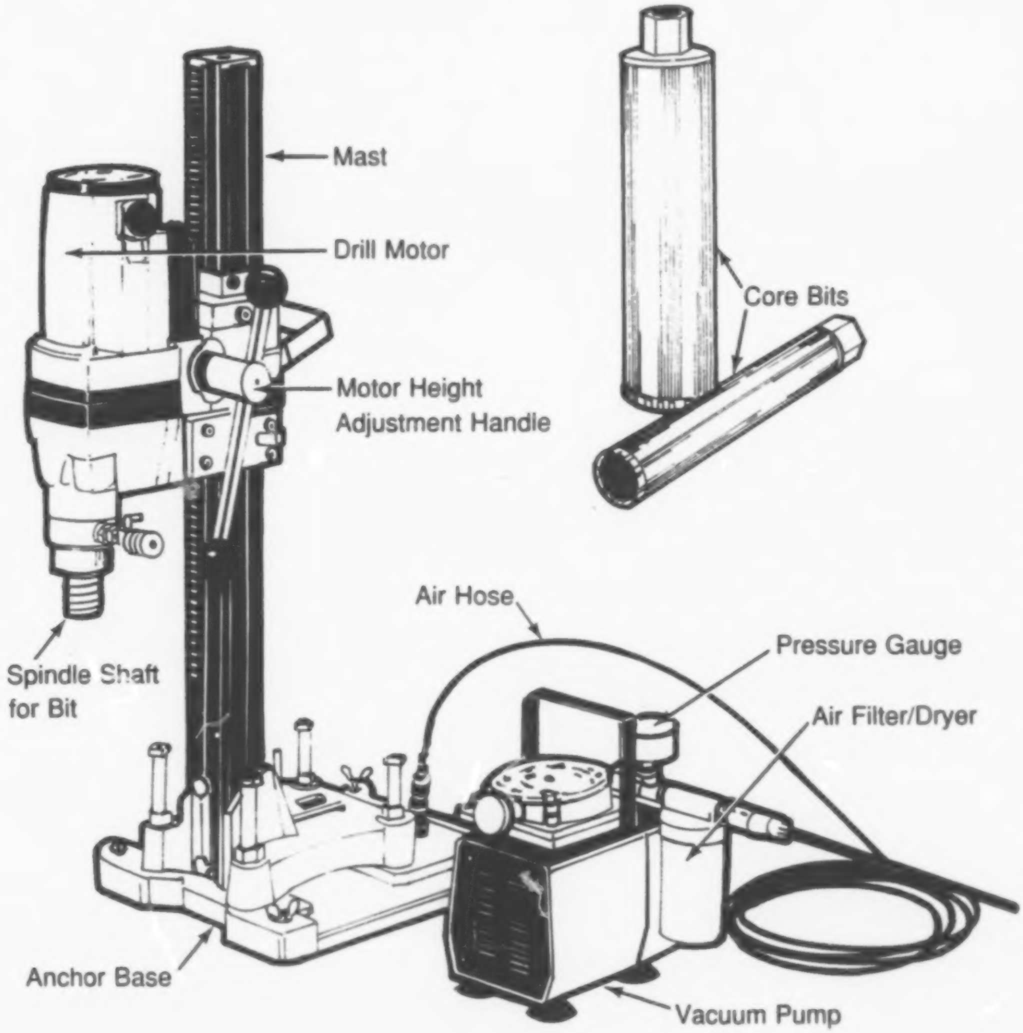
d. Never drill while off balance.

Note: Make sure that your footing and body position are such that you will not lose balance in the event that the unexpected happens.

e. Always wear eye protection.

20. **Parts of a core drilling machine** (Figure 10)

Figure 10


Mast
Drill Motor
Core Bits
Motor Height Adjustment Handle
Spindle Shaft for Bit
Air Hose
Pressure Gauge
Air Filter/Dryer
Anchor Base
Vacuum Pump

Information Sheet

21. **Safety rules for using a core drilling machine**

    a. Ensure that the core drilling machine is securely mounted to the surface to be drilled.

    b. Never leave the machine drilling while unattended.

    c. Do not try to force the drill to cut faster than suggested by the manufacturer.

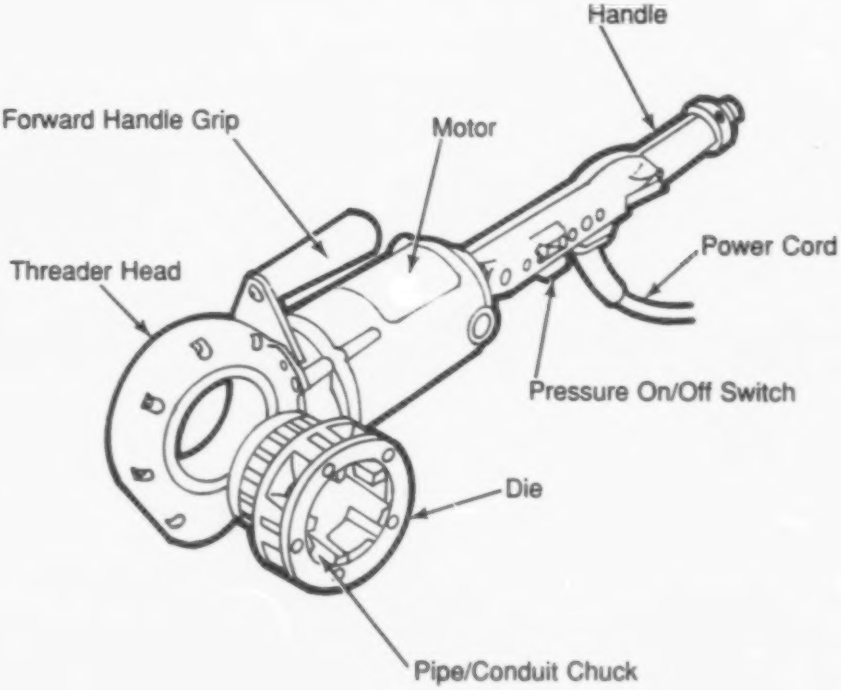
    d. Never drill while off balance.

    Note: Make sure that your footing and body position are such that you will not lose balance in the event that the unexpected happens.

    e. Always wear eye protection.

22. **Parts of a portable power threader** (Figure 11)

Figure 11


Handle
Forward Handle Grip
Motor
Power Cord
Threader Head
Pressure On/Off Switch
Die
Pipe/Conduit Chuck

Information Sheet

23. Safety rules for using portable power threaders

a. Always wear eye protection.

b. Always wear tight-fitting clothing, tie back long hair, and remove dangling jewelry.

c. Use gloves when handling pipe/conduit.

d. Never place hands near turning pipe/conduit.

e. Let threader come to a complete stop before removing pipe/conduit or reversing direction.

f. Always use a brush, not your hands, to clear thread cuttings.

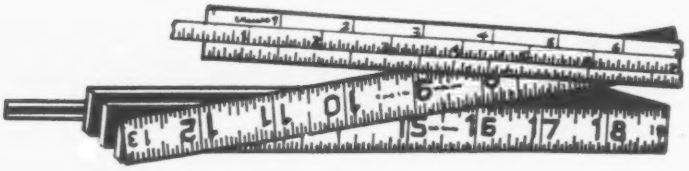
g. Never operate power threader while off balance.

Note: Make sure that your footing and body position are such that you will not lose balance in the event that the unexpected happens.

24. Typical rules and scales (Figures 12 - 14)

a. Six-foot folding rule

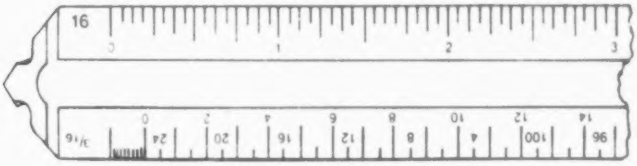
Figure 12



Information Sheet

b. Architect's scale

Figure 13


16
0
1
2
3
3/16
24
20
16
12
8
4
100
96

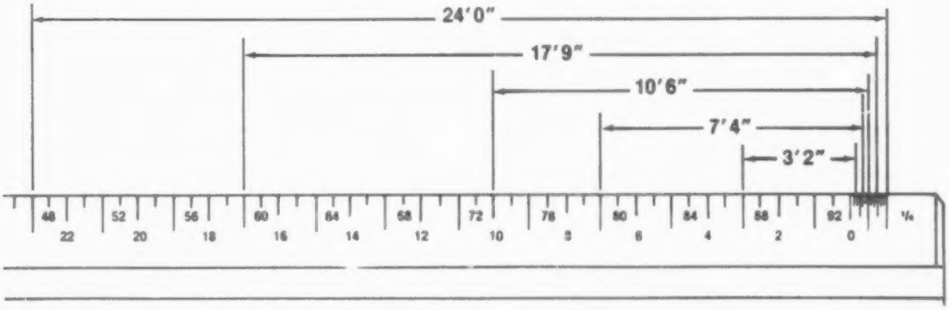
Scale ratios found on architect's scale:

12″ = 1′ - 0″—Full size
6″ = 1′ - 0″—Half size
3″ = 1′ - 0″—¼ size
1½″= 1′ - 0″—⅛ size
1″ = 1′ - 0″—1/12 size
¾″ = 1′ - 0″—1/16 size

½″ = 1′ - 0″—1/24 size
⅜″ = 1′ - 0″—1/32 size
¼″ = 1′ - 0″—1/48 size
3/16″ = 1′ - 0″—1/64 size
⅛″ = 1′ - 0″—1/96 size
3/32″ = 1′ - 0″—1/128 size

Note: An architect's scale is used to measure distances on prints. A typical blueprint may be drawn ¼-inch equals 1 foot. If such is the case, the scale is laid down by the line to be measured, using the ¼-inch scale. If the line is 7 units long, it will equal 7 feet.

Example: Figure 14

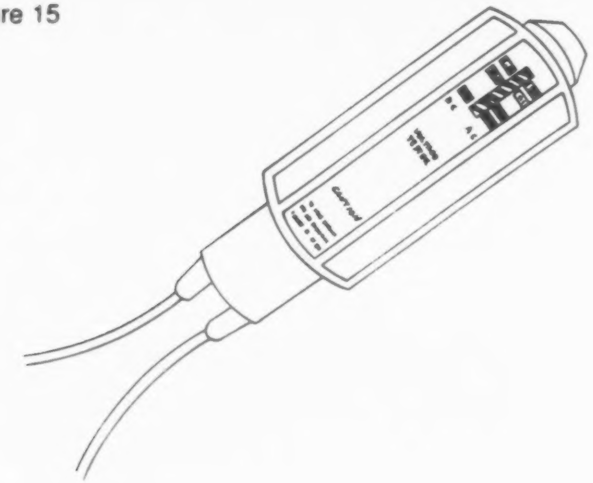

24′0″
17′9″
10′6″
7′4″
3′2″
48
52
56
60
64
68
72
76
80
84
88
92
¼
22
20
18
16
14
12
10
8
6
4
2
0

Information Sheet

25. **Typical test equipment** (Figures 15-18)

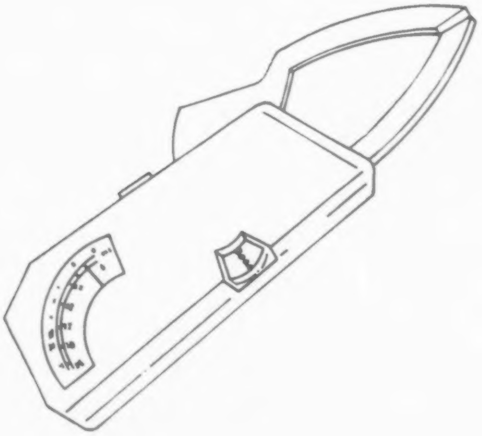
    a. **Voltage tester** — Used to determine the presence of voltage at a power source; indicates *approximate* value of voltage present

    Figure 15



    b. **Clamp-on ammeter** — Designed to clamp around an energized conductor and indicate the value of the current flowing through the conductor; can measure higher current values than a VOM can

    Figure 16

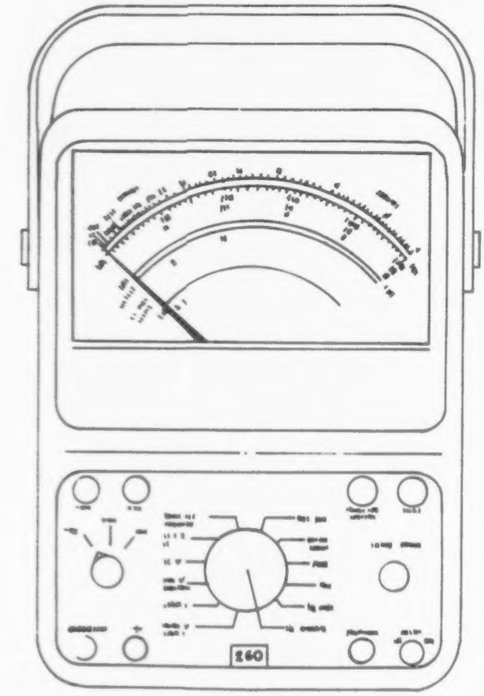


Information Sheet

c. **Permanent magnet moving coil multimeter (VOM)** — Designed to indicate specific quantities of voltage, resistance, or amperage

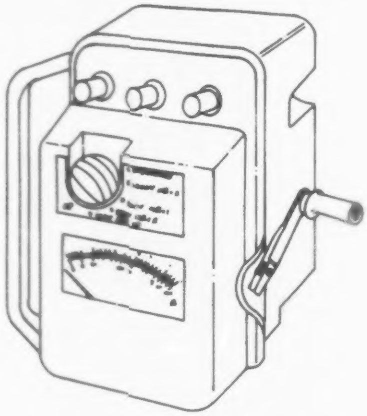
Note: "VOM" means volt-ohm-meter.

Figure 17



d. **Megometer (Megger)** — Typically used to test conductor insulation; able to measure insulation or ground resistance of several million ohms

Figure 18



Specialty Tools and Equipment
Unit 5

Assignment Sheet 1—Use an Architect's Scale

Name ______________________________ Overall Rating __________

Evaluation Criteria	**Rating**
All ten problems computed	______
Ten of ten answers correct per instructor's evaluation	______

Directions: Draw lines to the lengths indicated for each of the following scales.

A. Using the ⅛″ = 1′-0″ scale, draw a line equal to 14′-0″

B. Using the ¼″ = 1′-0″ scale, draw a line equal to 7′-6″.

C. Using the ½″ = 1′-0″ scale, draw a line equal to 2′-3″.

D. Using the 1″ = 1′-0″ scale, draw a line equal to 1′-7″.

E. Using the 3⁄16″ = 1′-0″ scale, draw a line equal to 9′-0″.

F. Using the ¾″ = 1′-0″ scale, draw a line equal to 2′-11″.

Assignment Sheet 1

G. Using the 1½″ = 1′-0″ scale, draw a line equal to 2′-3½″.

H. Using the 3″ = 1′-0″ scale, draw a line equal to 3¾″.

Specialty Tools and Equipment
Unit 5

Job Sheet 1—Use a Hydraulic Knockout Punch

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

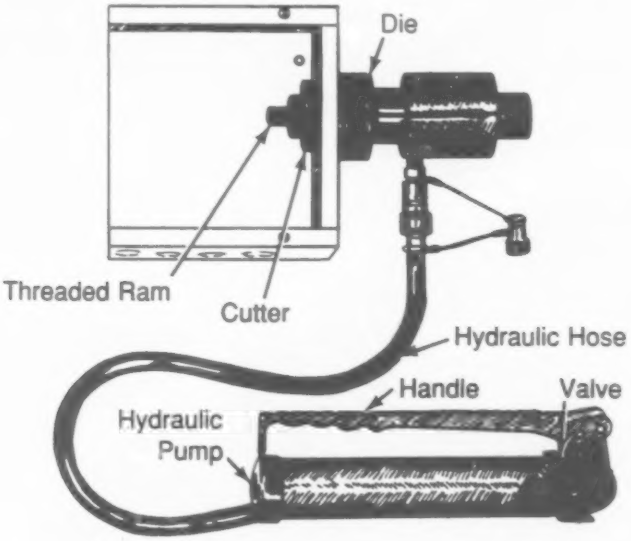
Evaluation Criteria	Rating
Gathered and used appropriate equipment and materials	______
Performed procedure safely	______
Performed all steps in procedure	______
Performed steps in correct sequence	______
Cleaned work area	______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the above criteria.

A. Equipment and materials

Hydraulic knockout punch with hand pump (Figure 1)

Figure 1



Die
Threaded Ram
Cutter
Hydraulic Hose
Handle
Valve
Hydraulic Pump

Job Sheet 1

Instructions for knockout punch
Drill motor
Metal drill bit large enough to accept the knockout punch bolt
Vise, if metal to be cut is not fastened to a wall, or if metal is too small to hold
Eye protection
Heavy-duty extension cord
Center punch
Gloves
Metal to be punched

Note: Most punches are rated up to 10-gauge metal.

B. Procedure

☐ 1. Read instructions for hydraulic knockout set.

☐ 2. Assemble hydraulic knockout set, referring to instructions and to Figure 1.

☐ 3. Put on eye protection.

☐ 4. Fasten metal to be punched in vise if necessary.

☐ 5. Put on gloves.

☐ 6. Use center punch to make an indentation in the center of the space to be knocked out.

☐ 7. Place drill bit on indentation made with center punch, and drill a hole slightly larger than the knockout punch bolt.

Caution: Hold the drill firmly while drilling. A loose grip could cause an accident. Remember that the drill will be hot. Use caution until it cools.

☐ 8. Separate knockout punch cutter from die and threaded ram.

☐ 9. Insert threaded ram through drilled hole; replace cutter on threaded ram.

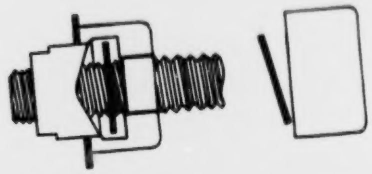
☐ 10. Close hydraulic valve; pump handle until cutter pulls through metal.

Note: After cutter is pulled through, the knockout punch is easily removed.

Job Sheet 1

☐ 11. Open the valve and remove cutter from threaded ram; shake out punched metal. (Figure 2)

Figure 2



Slug falls free in die. Tip die to remove slug.

☐ 12. Replace cutter on ram, making sure that it is properly lubricated.

Note: Have the instructor evaluate your work.

☐ 13. Clean work area, and put away equipment and materials.

Evaluator's Comments: ____

____

____

Specialty Tools and Equipment
Unit 5

Job Sheet 2—Bend a 90-Degree Stub Using a Hydraulic Pipe Bender

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	**Rating**
Gathered and used appropriate equipment and materials	______
Performed procedure safely	______
Performed all steps in procedure	______
Performed steps in correct sequence	______
Cleaned work area	______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the above criteria.

A. Equipment and materials

Hydraulic pipe bender
5 feet of 1-inch rigid galvanized conduit
Tape
Marking pencil

B. Procedure

Note: The procedure that follows is specifically for a Greenlee #880 bender. Other benders may vary slightly in measurements, but the procedure will be basically the same.

☐ 1. Assemble hydraulic bender using a 1-inch shoe and pipe supports.

☐ 2. Check chart on bender for minimum stub length, required deduction for stub, and ram travel measurement. Record data.

- Minimum stub length = ________________
- Stub deduction = ________________
- Ram travel = ________________

Job Sheet 2

☐ 3. Mark stub length (24 inches) on pipe.

☐ 4. Subtract stub deduction measurement from 24-inch mark, and make a second mark at that point.

☐ 5. Place pipe in bender shoe, matching center mark of shoe with second mark on pipe.

☐ 6. Close hydraulic pump valve, and pump handle until ram travel gauge indicates amount of travel for a 1-inch pipe with a 90-degree bend.

☐ 7. Release hydraulic pump valve, and allow ram to return fully before removing pipe.

☐ 8. Check height of stub and accuracy of 90-degree bend.

Note: Show work to instructor for evaluation.

☐ 9. Disassemble bender, clean work area, and return equipment and materials to their proper places.

Evaluator's Comments: ____

____

____

Specialty Tools and Equipment
Unit 5

Job Sheet 3—Make Offset and 90-Degree Bends Using An Electric PVC Heater

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
Gathered and used appropriate equipment and materials	______
Performed procedure safely	______
Performed all steps in procedure	______
Performed steps in correct sequence	______
Cleaned work area	______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the above criteria.

A. Equipment and materials

10 feet of ½-inch PVC conduit

Note: Check code reference on minimum radius for PVC.

Electric PVC heater
Instructions for PVC heater
Small pail of water
Shop rag or sponge
Piece of board at least 1 inch thick and as wide as desired offset
Nails to tack up piece of board
Eye protection
Gloves

B. Procedure for heating conduit and making a 90-degree bend

☐ 1. Read instructions for PVC heater.

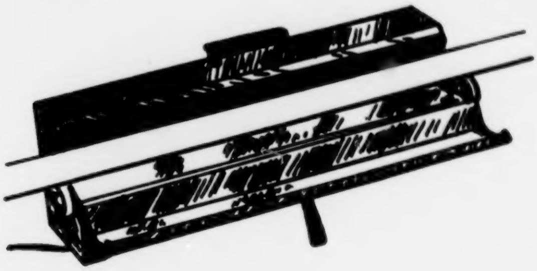
☐ 2. Put on eye protection and gloves.

Job Sheet 3

☐ 3. Plug in PVC heater and turn on; allow unit to preheat for 15 minutes in closed position.

☐ 4. Open unit and insert PVC as shown in Figure 1.

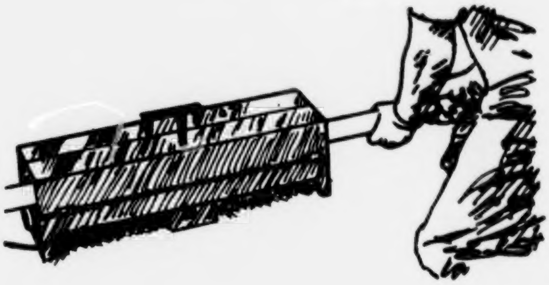
Figure 1



☐ 5. Close unit, and rotate PVC for 1 to 2 minutes or until it becomes pliable enough for bending. (Figure 2)

Note: Constantly turn conduit as it heats.

Figure 2



☐ 6. Remove PVC from heating chamber when it becomes soft and is easily bent.

Caution: Conduit will be very hot. Handle it carefully to avoid burns.

Note: Experience will help in determining when PVC is pliable for bending. Make sure that conduit is adequately heated. Larger pieces of conduit tend to kink unless adequately heated.

Job Sheet 3

☐ 7. Turn off PVC heater.

☐ 8. Form the 90-degree bend by hand on a flat surface.

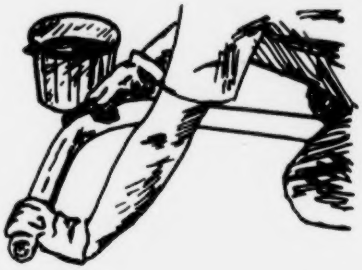
Note: Another method of forming the 90-degree bend is to push the conduit into a corner of the room, leaving the desired amount of straight conduit on each side of the bend.

☐ 9. Apply water-soaked rag or sponge to PVC to set the bend (Figure 3)

Caution: Do not use water next to the electric heater because of shock hazard.

Note: If bend is made in the corner of the room, an alternate method of setting the bend is to use straight boards to hold the conduit against the wall until it cools and hardens.

Figure 3



C. Procedure for heating conduit and making an offset bend

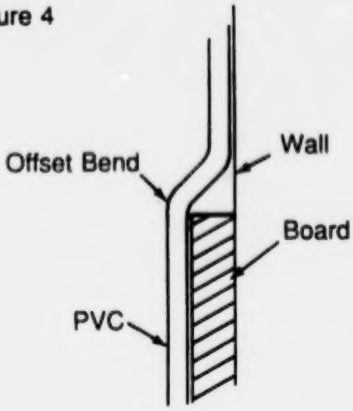
☐ 1. Determine amount of offset desired.

☐ 2. Turn on PVC heater and allow it to preheat for 15 minutes in closed position.

Job Sheet 3

☐ 3. Nail prepared piece of board to wall so that PVC may be shaped by placing it against the wall and then bending it away from the wall to lie parallel to outer edge of board as shown in Figure 4.

Figure 4



☐ 4. Open PVC heater, and insert PVC.

☐ 5. Close unit, and rotate PVC for one to two minutes or until it becomes pliable enough for bending.

☐ 6. Remove PVC from heating chamber when it becomes soft and is easily bent.

> **Caution: Conduit will be very hot. Handle it carefully to avoid burns.**

☐ 7. Turn off PVC heater.

☐ 8. Lay conduit against wall and against board as shown in Figure 4, holding the ends against the board and the wall until PVC cools and hardens.

Note: Show work to instructor for evaluation and comment.

☐ 9. De-energize PVC heater.

☐ 10. Clean work area and put away all equipment and materials.

Evaluator's Comments: ______________________________

____

____

Specialty Tools and Equipment
Unit 5

Job Sheet 4—Cut, Ream, and Thread Rigid Conduit with a Power Threader

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	**Rating**
Gathered and used appropriate equipment and materials	______
Performed procedure safely	______
Performed all steps in procedure	______
Performed steps in correct sequence	______
Cleaned work area	______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the above criteria.

A. Equipment and materials

Power threader
Stand for power threader
Hacksaw
Pipe reamer accessory
Adjustable die head accessory
Tool carriage accessory
Carriage lever accessory
Instructions for power threader and accessories
Oiler and thread-cutting oil
Clean cloth
Eye protection
Gloves
Length of steel pipe

B. Procedure

☐ 1. Read instructions for power threader and accessories.

☐ 2. Install power threader on stand.

Job Sheet 4

☐ 3. Install pipe reamer, adjustable die head, tool carriage, and carriage lever on power threader.

☐ 4. Put on eye protection and gloves.

☐ 5. Insert pipe into power threader, allowing pipe to extend far enough to clear chuck; tighten chuck jaws and rear centering device.

☐ 6. Mark pipe at point where cut is to be made, and then cut with hacksaw.

☐ 7. Place reamer in pipe end, allowing reamer handle to rest against tool support bar.

☐ 8. Turn on motor.

☐ 9. Press reamer into pipe to remove burrs.

☐ 10. Turn off motor, and lay reamer against tool rest.

☐ 11. Place threader die head on pipe.

☐ 12. Cut required number of threads, keeping oil on die stock until threads are cut.

☐ 13. Turn off motor.

Caution: Always allow machine to come to a complete stop before reversing direction.

☐ 14. Turn on motor, turn power drive switch to "reverse," and remove threader from pipe.

☐ 15. De-energize power threader.

Job Sheet 4

Note: Show threaded pipe to instructor for evaluation and comments.

☐ 16. Dismantle equipment, clean work area, and put away all materials and equipment.

Evaluator's Comments: ______________________________

____

____

Specialty Tools and Equipment
Unit 5

Job Sheet 5—Measure Resistance Using a VOM

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	**Rating**
Gathered and used appropriate equipment and materials	______
Performed procedure safely	______
Performed all steps in procedure	______
Performed steps in correct sequence	______
Cleaned work area	______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the above criteria.

A. Equipment and materials

Multimeter with test leads
Various resistors wrapped in masking tape to conceal their values, and numbered for reference

B. Procedure

Caution: Never check resistance on a live circuit as this can severely damage the instrument.

☐ 1. Position meter to correct function position.

☐ 2. Position meter range switch to one of the resistance scales.

☐ 3. Insert meter leads in correct meter jacks, observing polarity.

☐ 4. Connect meter across component to be checked.

Job Sheet 5

☐ 5. Determine correct meter position closest to center scale or toward zero.

☐ 6. Remove leads from component and touch (short) leads together while using "Ohm's Zero Adjust" to position needle to the zero position.

☐ 7. Reconnect meter to component.

☐ 8. Read meter for Ohmic value.

Note: Be sure to use proper scale, reading from right to left.

☐ 9. Turn off meter.

☐ 10. Record your readings below:

- Resistor #1 ______________________________
- Resistor #2 ______________________________
- Resistor #3 ______________________________
- Resistor #4 ______________________________
- Resistor #5 ______________________________

Note: Show your results to the instructor.

Evaluator's Comments: ______________________________

____

____

Specialty Tools and Equipment
Unit 5

Job Sheet 6—Measure DC Voltages Using a VOM

Name ________________________ Attempt Number ________

Date ________________________ Overall Rating ________

Evaluation Criteria	**Rating**
Gathered and used appropriate equipment and materials	_____
Performed procedure safely	_____
Performed all steps in procedure	_____
Performed steps in correct sequence	_____
Cleaned work area	_____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the above criteria.

A. Equipment and materials

VOM with test leads
DC power source (power supply or battery)

B. Procedure

☐ 1. Position meter to correct function.

Examples: –DC, +DC, or AC

☐ 2. Observing polarity, connect meter leads to meter.

☐ 3. Determine correct range scale.

Note: Use highest range if voltage is unknown.

☐ 4. Turn on power supply.

☐ 5. Adjust output to any voltage less than 50 volts.

Job Sheet 6

☐ 6. Observing polarity, connect meter leads to circuit to be tested.

Note: Always hook VOM across the components or power source to be tested. If the indicator needle moves to the left, the lead polarity is wrong.

☐ 7. Record results below:

- DC source = ____________________
- Voltage reading = ____________________

☐ 8. Change the source voltage or measure a second battery.

- DC source = ____________________
- Voltage reading = ____________________

Note: Show your results to your instructor.

Evaluator's Comments: ____________________

____

____

Specialty Tools and Equipment
Unit 5

Job Sheet 7—Measure AC Voltages Using a VOM

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation Criteria	**Rating**
Gathered and used appropriate equipment and materials	_____
Performed procedure safely	_____
Performed all steps in procedure	_____
Performed steps in correct sequence	_____
Cleaned work area	_____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the above criteria.

A. Equipment and materials

VOM with test leads
Alternating current power source

Example: Duplex receptacle

B. Procedure

☐ 1. Position meter to correct function.

Examples: –DC, +DC, or AC

☐ 2. Observing polarity, connect meter leads to meter.

☐ 3. Determine correct range scale.

Note: Use highest range if voltage is unknown.

Job Sheet 7

☐ 4. Connect meter leads to circuit to be tested.

Note: Lead polarity is not important when measuring AC voltages because polarity changes at a rate of 60 cycles per second (USA).

☐ 5. Measure "line voltage" of power receptacle. (See Figure 1.)

> **Caution: 120 volts can cause injury or death. DO NOT touch the metal parts of the test leads while measuring.**

☐ 6. Set meter on lowest scale at which it will register.

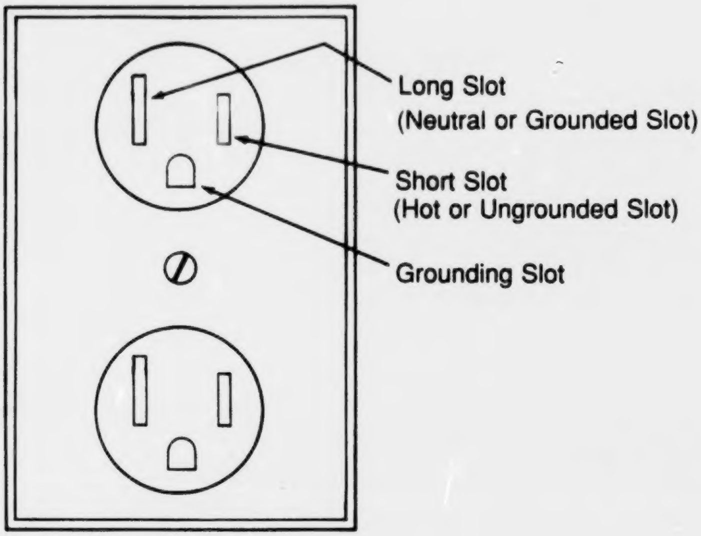
☐ 7. Record the readings below.

- Voltage between slotted jacks = ____________________
- Voltage between short slot and grounding slot = __________
- Voltage between long slot and ground slot = ____________

☐ 8. Disconnect meter leads.

☐ 9. Turn off meter.

Figure 1


Long Slot
(Neutral or Grounded Slot)
Short Slot
(Hot or Ungrounded Slot)
Grounding Slot

Job Sheet 7

Part 2: Three-Phase Power Source

A. Equipment and materials

VOM with test leads
Source of three-phase AC power such as a fused disconnect
Safety glasses

B. Procedure

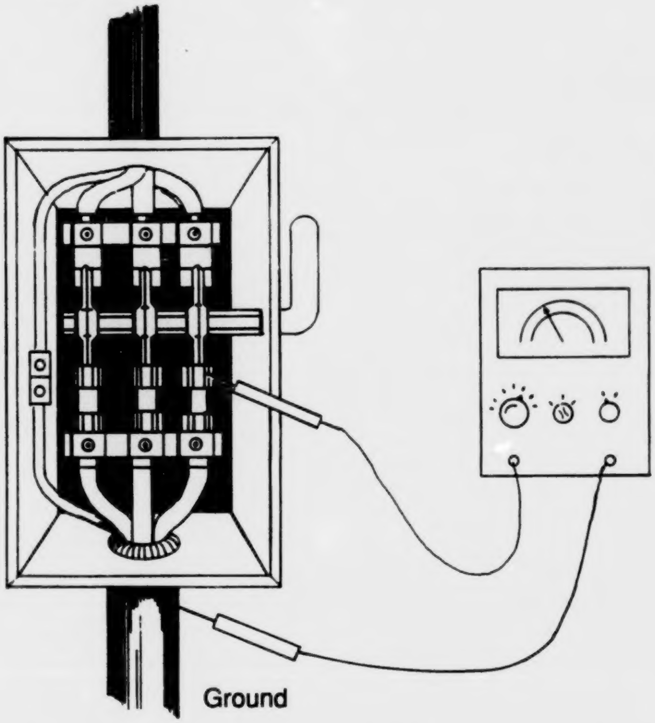
Note: The instructor must supervise each student.

☐ 1. Set multimeter for AC voltage measurement.

Note: Be sure setting is correct.

☐ 2. With instructor watching, *carefully* measure between each of the three terminals at the top of the disconnect and a ground terminal; record your measurements. (Figure 2)

Figure 2



Job Sheet 7

Voltages from terminals to ground

- ______________________________
- ______________________________
- ______________________________

☐ 3. Measure between first and second, first and third, and second and third terminals; record the readings below:

Voltages between terminals

- 1 to 2 = ________________________
- 1 to 3 = ________________________
- 2 to 3 = ________________________

Note: Show your measurements to your instructor.

☐ 4. Disconnect meter leads.

☐ 5. Turn off meter.

☐ 6. Put equipment and materials away.

Evaluator's Comments: ______________________________

____

____

Specialty Tools and Equipment
Unit 5

Job Sheet 8—Measure Amperage Using a Clamp-on Ammeter

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	**Rating**
Gathered and used appropriate equipment and materials	______
Performed procedure safely	______
Performed all steps in procedure	______
Performed steps in correct sequence	______
Cleaned work area	______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the above criteria.

A. Equipment and materials

Clamp-on ammeter
Source of three-phase AC power

B. Procedure

☐ 1. Position meter to highest scale.

☐ 2. Clamp the tongs around the live conductor.

Caution: Use extreme care when clamping the tongs around the conductor. Remember live circuits can KILL or INJURE you.

Note: Place the tongs around only one conductor; failure to do so could result in inaccurate measurements.

☐ 3. Reposition the scale to the lowest readable scale.

Job Sheet 8

☐ 4. Record measurements below:

- Line 1 = ____________________
- Line 2 = ____________________
- Line 3 = ____________________

☐ 5. Put away equipment and materials.

Evaluator's Comments: ____________________

____

____

Specialty Tools and Equipment
Unit 5

Job Sheet 9—Determine the Current of a Multiple Loop Using a Clamp-on Ammeter

Name ______________________________ Attempt Number __________

Date ______________________________ Overall Rating __________

Evaluation Criteria	**Rating**
Gathered and used appropriate equipment and materials	______
Performed procedure safely	______
Performed all steps in procedure	______
Performed steps in correct sequence	______
Cleaned work area	______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the above criteria.

A. Equipment and materials

Clamp-on ammeter
AC power source with a load (see the instructor)

B. Procedure

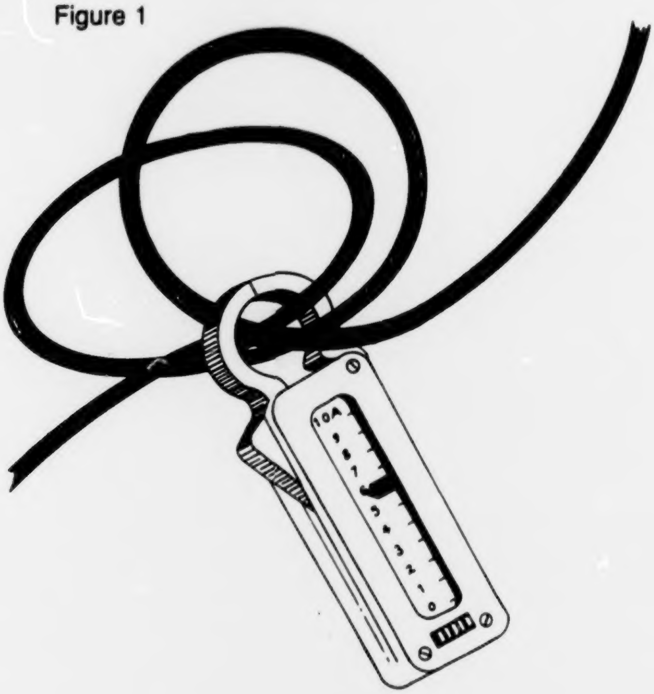
☐ 1. Form three loops in one conductor feeding the load.

☐ 2. Tape the loops tightly together.

Job Sheet 9

☐ 3. Clamp the tongs through the loops. (Figure 1)

Figure 1



☐ 4. Read the meter and record.

Initial measurement = ________________________________

☐ 5. Divide reading by the number of loops (3) and record the actual current value.

Actual current value = ________________________________

Note: Show your results to the instructor.

☐ 6. Put equipment and materials away.

Evaluator's Comments: ________________________________

____

____

Specialty Tools and Equipment
Unit 5

Job Sheet 10—Check Conductor Insulation with a Megger

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	**Rating**
Gathered and used appropriate equipment and materials	______
Performed procedure safely	______
Performed all steps in procedure	______
Performed steps in correct sequence	______
Cleaned work area	______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the above criteria.

A. Equipment and materials

Megger
20-foot run of conduit with three #12 THHN conductors (one conductor should have a slight nick in the insulation approximately midway)
Pouch tools

B. Procedure

☐ 1. Isolate each conductor. Be sure conductor ends do not touch each other or the conduit.

☐ 2. Clamp the red lead to the conduit.

☐ 3. Clamp the black lead to one of the conductors.

☐ 4. Record reading.

Job Sheet 10

☐ 5. Repeat steps 3 and 4 with the other two conductors.

- Conductor 1 = ______________________________
- Conductor 2 = ______________________________
- Conductor 3 = ______________________________

☐ 6. From your readings, determine which conductor is bad.

Note: Show your results to the instructor.

☐ 7. Put equipment and materials away.

Evaluator's Comments: ______________________________

____

____

Using Trade Information
Unit 6

Objective Sheet

Unit Objective

After completing this unit, the student should be able to locate specific wiring installation information in the *National Electrical Code*. The student should demonstrate these competencies by completing the assignment sheets and scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to using trade information with their correct definitions.
2. State the purpose of the *National Electrical Code*.
3. List factors that are not covered by the *National Electrical Code*.
4. State the intent of the *National Electrical Code* regarding mandatory enforcement.
5. Match *National Electrical Code* chapter numbers with their areas of application.
6. Arrange in order the sequence of organizational components of *National Electrical Code* information.
7. Arrange in order the steps for finding information in the *National Electrical Code*.
8. Use the *National Electrical Code* index to answer questions about *Code* sections. (Assignment Sheet 1)
9. Use the *National Electrical Code* introduction and first chapter to define terms. (Assignment Sheet 2)
10. Use the *National Electrical Code* to answer general questions related to residential wiring. (Assignment Sheet 3)
11. Use the *National Electrical Code* to locate allowable ampacities for various conductors. (Assignment Sheet 4)
12. Use the *National Electrical Code* to interpret conduit fill tables. (Assignment Sheet 5)
13. Find information in the *National Electrical Code*. (Assignment Sheet 6)

Using Trade Information
Unit 6

Suggested Activities

Instructional Plan

Preparation

1. Read the unit carefully and plan for instruction. Study the specific objectives to determine the order in which you will present them.

2. Review Teaching Suggestions section that follows. Plan for classroom activities.

3. Prepare activity sheets covering service drop clearance, sizing grounded conductors, and working clearances for use as a group activity in finding and interpreting the appropriate codes.

   Note: A good source for activity is the *NEC Handbook 1993*. See Suggested Supplemental Resources section that follows.

4. Plan your presentation to take advantage of student learning styles and to accommodate special needs students.

5. Obtain handbook, videotape, and other resources to supplement instruction of this unit. See ordering information in the Suggested Supplemental Resources section that follows.

6. Develop teaching plan. Adjust for different learning styles.

7. Make copies of Unit Evaluation Form.

Delivery and Application

8. Provide students with unit of instruction.

9. Discuss unit and specific objectives.

10. Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic skills when applicable.

11. Discuss assignment sheets and schedule due dates. Review criteria for evaluation of these activities.

Suggested Activities

Evaluation

12. Discuss the use of the Unit Evaluation Form with students. Discuss the rating scale that will be used for student evaluation.

13. Make copies of the written test. Add or modify test items as needed.

14. Give written test.

15. Compile assignment sheet ratings and written test scores on the Unit Evaluation Form. Include any additional assignments.

16. Reteach and retest as required.

Teaching Suggestions

Note: Skill areas appearing in boldface type in the Teaching Suggestions refer to the academic and workplace skills identified by the American Society for Training and Development (ASTD) and the U.S. Department of Labor. These have been adapted by MAVCC.

1. Provide students with a copy of the *National Electrical Code*, and stress its purpose and importance.

2. Invite a local inspector to speak to the class. Skill area: **Listening**

3. Provide students with copies of local electrical codes. Skill areas: **Learning to learn, reading**

Resources Used in Developing This Unit

1. Early, Mark W., John M. Caloggero, and Richard H. Murray. *National Electrical Code 1993*. Quincy, MA: National Fire Protection Association, 1992.

2. Taylor, Mark. *Residential Wiring*. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1983.

3. Teague, Cash and Garner Pewewardy. *Industrial Electricity: In-Plant Distribution*. Stillwater, OK: Oklahoma Department of Vocational-Technical Education/Curriculum and Instructional Materials Center, 1984.

Suggested Activities

Suggested Supplemental Resources

1. Book — Earley, Mark W., John M. Caloggero, and Richard H. Murray. *National Electrical Code 1993*. Quincy, MA: National Fire Protection Association, 1992.

   This handbook helps the technician interpret the *NEC* and apply it to real situations. This official "user's guide" contains the entire text of the 1993 code—plus supplements. The handbook is a practical, time saving tool that answers the technician's questions and helps the technician work more efficiently to get the job done right.

2. Videotape — *National Electrical Code 1993 Changes.*

   This ¾-inch VHS or Betamax videotape provides helpful background on the code-making process as well as the purpose, intent, and applications of major changes. With hundreds of new requirements and important revisions in the 1993 *Code*, this videotape can be a time-saving learning tool.

   Order both the handbook and the videotape from:

   National Fire Protection Association
   1 Batterymarch Park
   P.O. Box 9101
   Quincy, MA 02269-9101

Instructions for Evaluating Student Performance

Assignment Sheets—Be sure the student understands the criteria on which the evaluation is based. Assign a point value to each criterion and convert the total points to a percentage for grading.

Job Sheets—Be sure the student understands the criteria on which the evaluation is based. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in either the teacher or student edition. Then observe the student performing the procedure. Rate both process and product.

> Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily achieved the step(s) for each checkpoint area. If the student is unable to correctly complete the procedure, have the student review the materials and try again.

Suggested Activities

> Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria which have been provided as part of the job sheet. Complete the rating by assigning a point value to each criterion and by converting the point total to a percentage for grading. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) which best fits your program needs.

Option A

4 - Skilled—Can perform job with no additional training.
3 - Moderately skilled—Has performed job during training program; limited additional training may be required.
2 - Limited skill—Has performed job during training program; additional training is required to develop skill.
1 - Unskilled—Is familiar with process, but is unable to perform job.

Option B

Yes—Can perform job with no additional training.

No—Is unable to perform job satisfactorily.

Using Trade Information
Unit 6

Answers to Assignment Sheets

Assignment Sheet 1

A. 513
B. 250-79
C. 370-D
D. 364-5
E. 410-8
F. 410-65(c)
G. 384-16
H. 551-4
I. 430-82(c)
K. 660-D

Assignment Sheet 2

A. Safeguarding; code section 90-1(a)
B. Chapter 9
C. Code section 100-A
   1. "The current in amperes that a conductor can carry continuously under the conditions of use without exceeding its temperature rating"
   2. "The circuit conductors between the final overcurrent device protecting the circuit and the outlet(s)"
   3. "A point on the wiring system at which current is taken to supply utilization equipment"
   4. "Service conductors made up in the form of a cable"
   5. "The permanent joining of metallic parts to form an electrically conductive path which will assure electrical continuity and the capacity to conduct safely any current likely to be imposed"
   6. "A conductor encased within material of composition or thickness that is not recognized by this *Code* as electrical insulation"
   7. "A contact device installed at the outlet for the connection of a single attachment plug"
   8. "The overhead service conductors from the last pole or other aerial support to and including the splices, if any, connecting to the service-entrance conductors at the building or other structure"
   9. "A unit of an electrical system that is intended to carry but not utilize electric energy"
   10. "A device, or group of devices, or other means by which the conductors of a circuit can be disconnected from their source of supply"
   11. "A general term including material, fittings, devices, appliances, fixtures, apparatus, and the like used as part of, or in connection with, an electrical installation"
   12. "Operation of equipment in excess of normal, full-load rating, or of a conductor in excess of rated ampacity which, when it persists for a sufficient length of time, would cause damage or dangerous overheating. A fault, such as a short circuit or ground fault, is not an overload"

Answers to Assignment Sheets

13. "The underground service conductors between the street main, including any risers at a pole or other structure or from transformers, and the first point of connection to the service-entrance conductors in a terminal box or meter or other enclosure with adequate space, inside or outside the building wall. Where there is no terminal box, meter, or other enclosure with adequate space, the point of connection shall be considered to be the point of entrance of the service conductors into the building"
14. "The words 'Thermally Protected' appearing on the nameplate of a motor-compressor indicate that the motor is provided with a thermal protector"
15. "So constructed or protected that exposure to the weather will not interfere with successful operation"
16 "Provided with a means to permit circulation of air sufficient to remove an excess of heat, fumes, or vapors"
17. "An overcurrent protective device that contains a heater element in addition to and affecting a renewable fusible member which opens the circuit. It is not designed to interrupt short-circuit currents"
18. "The raceway that encloses the service-entrance conductors"
19. "Capable of being reached quickly for operation, renewal, or inspections, without requiring those to whom ready access is requisite to climb over or remove obstacles or to resort to portable ladders, chairs, etc."
20. "Surrounded by a case, housing, fence, or wall which will prevent persons from accidentally contacting energized live parts"

Assignment Sheet 3

A. Yes; [illegible]70-20(a)
B. Current carrying capacity of electric conductors expressed in amperes; 100
C. No; 210-23

Assignment Sheet 4

A. 25 (cannot be fused over 20A)
B. 165
C. 195
D. 50 (cannot be fused over 30A)
E. 35 (cannot be fused over 30)
F. 25 (cannot be fused over 20A)
G. 150
H. 60

Answers to Assignment Sheets

Assignment Sheet 5

A. 1. 13
    2. 6
    3. 1
B. 1. 11
    2. 2
C. 1. 4
    2. 2
    3. 6
D. 1. 4
    2. 3

Assignment Sheet 6

Part 1

A. Article part A, *Code* section 250-1
    1. "Systems, circuits, and equipment required, permitted, or not permitted to be grounded"
    2. "Circuit conductor to be grounded on grounded systems"
    3. "Location of grounding connections"
    4. "Types and sizes of grounding and bonding conductors and electrodes"
    5. "Methods of grounding and bonding"
    6. "Conditions under which guards, isolation, or insulation may be substituted for grounding"
B. Article part B; *Code* section 250-6(a); True
C. Article part C; *Code* section 250-26(c); True
D. Provided; fault current; Article part G; *Code* section 250-70
E. Uninsulated; Article part G; *Code* section 250-73
F. Jumper; four exceptions; Article part G; *Code* section 250-74
G. Copper; Article part G; *Code* section 250-79(a)
H. Article part J; *Code* section 250-95; #8, #6, #3
I. Cases or frames; Article part L; *Code* section 250-122
J. Not; Article part K; *Code* section 250-113

Part 2

A. True; *Code* section 336-4(b)
B. 6 feet; *Code* section 336-13, ref. to 333-12(a)
C. False; *Code* section 345-3(a), ref. to 250-91(b)
D. True; *Code* section 346-1(b) exception
E. True; *Code* section 346-7(b)
F. True; *Code* section 347-8, table
G. True; *Code* section 348-7
H. True; *Code* section 349-4
I. True; *Code* section 350-3, exception 2
J. True; *Code* section 364-2

Answers to Assignment Sheets

Part 3

A. True; *Code* section 430-7(a)(2)
B. Motor control circuit; *Code* section 430-71
C. False; *Code* section 430-110(b)
D. True; *Code* section 440-22(a)
E. False; *Code* section 445-5
F. True; *Code* section 450-47
G. True; *Code* section 480-2, ref. to 480-9(b)
H. True; *Code* section 500-5
I. False; *Code* section 501-5(a)(1)

Part 4

A. Seven; *Code* section 230-2
B. False; *Code* section 240-4, ref. to Table 402.5
C. True; *Code* section 370-16(c)
D. Covers; *Code* section 370-28(c)
E. True; Note 5 to tables 310-16 through 310-19
F. 300-4; *Code* section 336-11
G. One minute; *Code* section 460-6(a)
H. True; *Code* section 500-3(b)(1)
I. False; *Code* section 680-6(a)(3)

Using Trade Information
Unit 6

Answers to Written Test

1. a. 15
   b. 2
   c. 16
   d. 1
   e. 17
   f. 7
   g. 9
   h. 14
   i. 3
   j. 11
   k. 6
   l. 12
   m. 5
   n. 13
   o. 10
   p. 4
   q. 8

2. Sets minimum standards for safeguarding persons and property from hazards arising from the use of electricity

3. a. Efficiency
   b. Convenience
   c. Good service

4. The *Code* is intended to be suitable for mandatory enforcement by the governmental authority having jurisdiction. Mandatory rules are characterized by the word "SHALL."

5. a. 8
   b. 6
   c. 1
   d. 9
   e. 7
   f. 5
   g. 2
   h. 4
   i. 3

6. a. 4
   b. 2
   c. 1
   d. 3
   e. 5

7. a. 3
   b. 4
   c. 1
   d. 5
   e. 2

Using Trade Information
Unit 6

Written Test

Name ______________________________ Score ______________

1. Match terms related to using trade information with their correct definitions. Write the correct numbers in the blanks. Definitions and terms are continued on the next page.

_____a. Develops electrical equipment standards

_____b. Develops standards for electrical machinery and equipment

_____c. Develops and publishes fire and industrial safety standards

_____d. Develops standards for electrical equipment and supplies

_____e. Tests equipment and lists items for use in specified situations

_____f. Standards developed to provide for safe building construction practices

_____g. Intentionally grounded system or circuit conductor

_____h. Book containing electrical specifications endorsed by NFPA and ANSI; used for legal and regulatory purposes in the interest of life and property protection

_____i. Permanent joining of metallic parts to form an electrically conductive path that will ensure electrical continuity and the capacity to conduct safely any current likely to be imposed

_____j. Conductor used to connect the grounding electrode to the equipment grounding conductor, to the grounded conductor, or to both, of the circuit at the service equipment or at the source of a separately derived system

1. American National Standards Institute (ANSI)
2. American Standard Association (ASA)
3. Bonding
4. Bonding jumpers
5. Bonding jumper circuit
6. Bonding jumper equipment
7. Building code
8. Grounded
9. Grounded conductor
10. Grounding conductor
11. Grounding electrode conductor
12. Jurisdiction
13. Mandatory enforcement
14. *National Electrical Code (NEC)*

Written Test

______k. Connections between two or more portions of the equipment grounding conductor

______l. Power, right, or authority to interpret the law (code)

______m. Connections between portions of a conductor in a circuit to maintain required ampacity of the circuit

______n. Governmental authority to demand compliance with the *National Electrical Code* requirements for electrical installations

______o. Conductor used to connect equipment of the grounded circuit of a wiring system to a grounding electrode or electrodes

______p. Pieces of wire or other conductors that connect different metal parts

______q. Connected to earth or to some conducting body that serves in place of the earth

15. National Electrical Manufacturers Association (NEMA)

16. National Fire Protection Association (NFPA)

17. Underwriters Laboratories (UL)

2. State the purpose of the *National Electrical Code*.

____

____

____

3. List factors that are not covered by the *National Electrical Code*.

a. ____

b. ____

c. ____

Written Test

4. State the intent of the *National Electrical Code* regarding mandatory enforcement.

____

____

____

5. Match *National Electrical Code* chapter numbers with their areas of application. Write the correct numbers in the blanks.

______a. Communications systems 1. Chapter 1

______b. Special equipment 2. Chapter 2

______c. General application 3. Chapter 3

______d. Tables and examples 4. Chapter 4

______e. Special conditions 5. Chapter 5

______f. Special occupancies 6. Chapter 6

______g. Wiring and protection 7. Chapter 7

______h. Equipment for general use 8. Chapter 8

______i. Wiring methods and materials 9. Chapter 9

6. Arrange in order the organizational components of *National Electrical Code* information. Write a "1" before the first step, a "2" before the second step, and so on.

______a. Numbered paragraphs

______b. Article

______c. Chapter

______d. Parts

______e. Numbered or lowercase lettered subparagraphs

Written Test

7. Arrange in order the steps for finding information in the *National Electrical Code*. Write a "1" before the first step, a "2" before the second step, and so on.

______a. Turn to article and section as designated.

______b. Read all related areas and exceptions.

______c. Refer to index for appropriate area of code.

______d. Cross-reference if code refers to another article.

______e. Locate specified area in question.

***Permission to duplicate this test is granted.**

Using Trade Information
Unit 6

Unit Evaluation Form

Student Name ________________________ Unit Rating __________

Assignment Sheet 1—Use the *National Electrical Code* Index to Answer Questions About *Code* Sections Rating ______

Comments: ________________________________

____

Assignment Sheet 2—Use the *National Electrical Code* Introduction and First Chapter to Define Terms Rating ______

Comments: ________________________________

____

Assignment Sheet 3—Use the *National Electrical Code* to Answer General Questions Related to Residential Wiring Rating ______

Comments: ________________________________

____

Assignment Sheet 4—Use the *National Electrical Code* to Locate Allowable Ampacities for Various Conductors Rating ______

Comments: ________________________________

____

Assignment Sheet 5—Use the *National Electrical Code* to Interpret Conduit Fill Tables Rating ______

Comments: ________________________________

____

Assignment Sheet 6—Find Information in the *National Electrical Code* Rating ______

Comments: ________________________________

____

Unit Evaluation Form

Written Test Scores

Pretest ______ Posttest ______ Other ______

Other ____

____

Teacher Signature ______________________________ Date ____________

Student Signature ______________________________ Date ____________

***Permission to duplicate this form is granted.**

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Using Trade Information
Unit 6

Information Sheet

1. **Terms and definitions**

   a. **American National Standards Institute (ANSI)** — Develops standards for electrical equipment and supplies

   b. **American Standard Association (ASA)** — Develops standards for electrical machinery and equipment

   c. **Bonding** — Permanent joining of metallic parts to form an electrically conductive path that will ensure electrical continuity and the capacity to conduct safely any current likely to be imposed

   d. **Bonding jumpers** — Pieces of wire or other conductors that connect different metal parts

   e. **Bonding jumper circuit** — Connections between portions of a conductor in a circuit to maintain required ampacity of the circuit

   f. **Bonding jumper equipment** -- Connections between two or more portions of the equipment grounding conductor

   g. **Building code** — Standards developed to provide for safe building construction practices

   h. **Grounded** — Connected to earth or to some conducting body that serves in place of the earth

   i. **Grounded conductor** — Intentionally grounded system or circuit conductor (neutral)

   j. **Grounding conductor** — Conductor used to connect equipment of the grounded circuit of a wiring system to a grounding electrode or electrodes

   k. **Grounding electrode conductor** — Conductor used to connect the grounding electrode to the equipment grounding conductor, to the grounded conductor, or to both, of the circuit at the service equipment or at the source of a separately derived system

   l. **Jurisdiction** — Power, right, or authority to interpret the law (code)

   m. **Mandatory enforcement** — Governmental authority to demand compliance with the *National Electrical Code* requirements for electrical installations

Information Sheet

n. ***National Electrical Code (NEC)*** — Book containing electrical specifications endorsed by NFPA and ANSI; used for legal and regulatory purposes in the interest of life and property protection

o. **National Electrical Manufacturers Association (NEMA)** — Develops electrical equipment standards

p. **National Fire Protection Association (NFPA)** — Develops and publishes fire and industrial safety standards

q. **Underwriters Laboratories (UL)** — Tests equipment and lists items for use in specified situations

2. **Purpose of the *National Electrical Code*** — Sets minimum standards for safeguarding persons and property from hazards arising from the use of electricity

3. **Factors that are not covered by the *National Electrical Code***

   a. Efficiency

   b. Convenience

   c. Good service

4. **Intent of the *National Electrical Code* regarding mandatory enforcement** — The *Code* is intended to be suitable for mandatory enforcement by the governmental authority having jurisdiction. Mandatory rules are characterized by the word "SHALL."

   Note: The legal inspector may grant exceptions (special permission) to code requirements, provided safety standards are maintained. States and municipalities may adopt their own electrical codes as long as these codes improve upon, not lessen, the requirements of the *NEC*.

5. ***National Electrical Code* chapter numbers and their areas of application**

   a. **Chapter 1** — General application, may be modified in later chapters

   b. **Chapter 2** — Wiring and protection

   c. **Chapter 3** — Wiring methods and materials

   d. **Chapter 4** — Equipment for general use

   e. **Chapter 5** — Special occupancies

   f. **Chapter 6** — Special equipment

   g. **Chapter 7** — Special conditions

   h. **Chapter 8** — Communications systems

   i. **Chapter 9** — Tables and examples

Information Sheet

6. **Sequence of organizational components of *National Electrical Code* information**

   a. **Chapter** — Covers broad area of code

      Example: Chapter — Wiring Design and Protection

   b. **Article** — Covers a specific part of the chapter

      Example: Article 210 — Branch circuits

   c. **Parts** — Covers a specific item of the article

      Example: Part B — Branch circuit ratings

   d. **Numbered paragraphs** — Cover a specific item of the part

      Example: Paragraph 19 — Conductors — Minimum ampacity and size

   e. **Numbered (1) or lowercase lettered (a) subparagraphs**

      Example: Subparagraph (b) — Household ranges and cooking appliances

7. **Steps for finding information in the *National Electrical Code***

   a. Refer to index for appropriate area of code.

      Example: Service drops

   b. Locate specified area in question.

      Example: Minimum size

   c. Turn to article and section as designated.

      Example: Service drops — minimum size — 230-23

   d. Read all related areas and exceptions.

Information Sheet

e. Cross-reference if *Code* refers to another article.

Note: It is imperative that *all* cross references be found and read, otherwise the improper answer may be used.

Example: **Incandescent lamps**, Art. 410; see also
    Hazardous (classified) locations
  Guards
    Aircraft hangers, 513-5(a)
    Garages, 511-7(a) and (b)
    Theater dressing rooms, 520-72
  Lamp wattage, marking on fixture, 410-70
  Medium and mogul bases, 410-53
  Snap switches for, 380-14

Using Trade Information
Unit 6

Assignment Sheet 1—Use the *National Electrical Code* (*NEC*) Index to Answer Questions About Code Sections

Name ______________________ Overall Rating __________

Evaluation criteria	**Rating**
Assignment answers complete	______
Eight of ten answers correct per Answers to Assignment Sheet 1	______

Directions: Use the *National Electrical Code* index to answer the following questions. Write the correct answers in the blanks.

A. What article covers aircraft hangers?

Article ______________________

B. What section covers bonding jumpers?

Article ______________________

C. What section covers boxes over 600 volts?

Code section ______________________

D. What section covers support of busways?

Code section ______________________

E. What section covers light fixtures in clothes closets?

Code section ______________________

F. What section covers the clearances of recessed lighting fixtures?

Code section ______________________

G. What section covers overload protection in panelboards?

Code section ______________________

Assignment Sheet 1

H. What section covers general requirements in recreational vehicles?

Code section ______________________________

I. What section covers construction specifications for rheostats?

Code section ______________________________

J. What section covers guarding and grounding on x-ray equipment?

Code section ______________________________

Using Trade Information
Unit 6

Assignment Sheet 2—Use the *National Electrical Code* Introduction and First Chapter to Define Terms

Name ______________________________ Overall Rating __________

Evaluation criteria	Rating
Assignment answers complete	______
Twenty-three of twenty-five answers correct per Answers to Assignment Sheet 2	______

Directions: Find the following information using the *National Electrical Code* table of contents, introduction, and first chapter. Indicate the code section number(s) that apply to each statement.

A. The purpose of this code is the practical ____________________ of persons and property from hazards arising from the use of electricity.

Code section ______________________________

B. Tables and examples are found in ____________________ ____________________

C. Define the following terms. *Code* section ____________________

1. Ampacity — ______________________________

____

____

2. Branch circuit — ______________________________

____

____

3. Outlet — ______________________________

____

____

Assignment Sheet 2

4. Service cable — ______

5. Bonding — ______

6. Covered conductor — ______

7. Receptacle — ______

8. Service drop — ______

9. Device — ______

10. Disconnecting means — ______

11. Equipment — ______

Assignment Sheet 2

12. Overload — ______________________________

13. Service lateral — ______________________________

14. Thermally protected — ______________________________

15. Weatherproof — ______________________________

16. Ventilated — ______________________________

17. Thermal cutout — ______________________________

18. Service raceway — ______________________________

19. Readily accessible — ______________________________

20. Enclosed — ______________________________

Using Trade Information
Unit 6

Assignment Sheet 3—Use the *National Electrical Code* to Answer General Questions Related to Residential Wiring Practices

Name ________________________________ Overall Rating __________

Evaluation criteria	**Rating**
Assignment answers complete	______
All answers correct per Answers to Assignment Sheet 3	______

Directions: Give article number and answer to each of the following questions.

Note: The problem solving steps listed below are taken from Objective 7 of the Information Sheet.

Example: Are ground-fault circuit-interrupters required on 125 volt single-phase 20-amp temporary construction receptacles?

Step 1: Refer to index: "**Construction sites**" is located and "ground-fault circuit-interrupter, protection for" is listed.

Step 2: Note listing of article (305).

Step 3: Find the page number for the article on branch circuits; turn to it (70-143).

Step 4: Find section number by turning pages in article (305-6[a]).

Answer: From the article on branch circuits, 15- and 20-amp receptacles on temporary poles do require ground-fault circuit-interrupters; 305-6(a).

Problems

A. Do boxes made of metal need to be corrosion resistant?

Answer: ________________________________ Article No. __________

B. What is the definition of "ampacity?"

Answer: ________________________________ Article No. __________

C. Can a branch circuit used for lighting purposes and rated at 20 amps have a 12-amp dishwasher or other fixed appliance connected to it?

Answer: ________________________________ Article No. __________

Using Trade Information
Unit 6

Assignment Sheet 4—Use the *National Electrical Code* to Locate Allowable Ampacities for Various Conductors

Name ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
Assignment answers complete	______
Six of eight answers correct per Answers to Assignment Sheet 4	______

Directions: List the various ampacities for the conductors as listed, using Tables 310-16 through 310-17.

Example: List the ampacities for the following conductors when used in a 3 conductor cable with an ambient temperature of 100°F.

A. #12 TW copper ____________
B. #6 TW copper ____________

Answer: A. 25 amps (cannot be fused over 20 amps)
B. 55 amps

Problems

What is the allowable ampacity for the following single-insulated copper conductors used in free air if the ambient temperature is 90°F?

A. 14 TW ____________

B. 1 TW ____________

C. 1 THWN ____________

D. 10 THW ____________

What is the allowable ampacity for the following aluminum conductors when used in a 3-wire cable, if the ambient temperature is 70°F?

E. 10 TW ____________

F. 12 TW ____________

G. 1/0 TW ____________

H. 6 TW ____________

Using Trade Information
Unit 6

Assignment Sheet 5—Use the *National Electrical Code* to Interpret Conduit Fill Tables

Name ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
Assignment answers complete	______
Eight of ten answers correct per Answers to Assignment Sheet 5	______

Directions: List the maximum number of conductors allowed in the following conduits.

A. ½″ conduit

   1. 14 THHN ____________
   2. 10 THWN ____________
   3. 6 TW ____________

B. ¾″ conduit

   1. 10 THWN ____________
   2. 4 THWN ____________

C. 1″ conduit

   1. 6 TW ____________
   2. 3 TW ____________
   3. 6 THWN ____________

D. 2″ conduit

   1. 4/0 THWN ____________
   2. 4/0 TW ____________

Using Trade Information
Unit 6

Assignment Sheet 6—Find Information in the NEC

Name ____ Overall Rating __________

Evaluation criteria	Rating
Assignment answers complete	______
Part 1—Thirteen of fifteen answers correct per Answers to Assignment Sheet 6	______
Part 2—Eight of ten answers correct per Answers to Assignment Sheet 6	______
Part 3—Seven of nine answers correct per Answers to Assignment Sheet 6	______
Part 4—Seven of nine answers correct per Answers to Assignment Sheet 6	______

Part 1

Directions: Use the *National Electrical Code*, Article 250, to find the following information. Write the correct answers in the appropriate blanks.

A. Article 250-1 covers general and specific requirements for grounding and bonding of electrical installations.

List the six specific requirements detailed in the *Code*.

Article part ________________________________ *Code* section ____________

1. ____

____

2. ____

____

3. ____

____

Assignment Sheet 6

4. ____

____

5. ____

____

6. ____

____

B. Portable generators (in some instances) are not required to be grounded to earth.

Article part ______________________ *Code* section ________

True ______ False ______

C. In grounding separately derived AC systems, "the grounding electrode shall be as near as practicable to and preferably in the same area as the grounding conductor connection to the system."

Article part ______________________ *Code* section ________

True ______ False ______

D. "Bonding shall be ______________ where necessary to assure electrical continuity and the capacity to conduct safely any ______________ ______________ likely to be imposed."

Article part ______________________ *Code* section ________

E. "The metal covering of service cable having an ______________ grounded service conductor in continuous electrical contact with its metallic armor or tape shall be considered to be grounded."

Article part ______________________ *Code* section ________

F. "An equipment bonding ______________ shall be used to connect the grounding terminal of a grounding-type receptacle to a grounded box." How many exceptions are there? ______

Article part ______________________ *Code* section ________

Assignment Sheet 6

G. "Main and equipment bonding jumpers shall be of ________________ or other corrosion-resistant material."

Article part ________________________________ *Code* section ____________

H. "The size of copper, aluminum, or copper-clad aluminum equipment grounding conductors shall not be less than given in Table 250-95." Give the sizes of copper equipment grounding conductors for 100-ampere, 200-ampere, and 400-ampere circuits.

Article part ________________________________ *Code* section ____________

100A = ____________

200A = ____________

400A = ____________

I. "________________ or ________________ of instrument transformers shall be grounded where accessible to other than qualified persons."

Article part ________________________________ *Code* section ____________

J. In making grounding conductor connections, "required grounding conductors and bonding jumpers shall be connected by pressure connectors, clamps, or other approved means. Connection devices of fittings that depend on solder shall ________________ be used."

Article part ________________________________ *Code* section ____________

Part 2

Directions: Use the *National Electrical Code*, Articles 336 through 364, to find the following information. Write the correct answers in the appropriate blanks.

A. Type NM cable shall not be installed in a shallow chase in masonry walls.

True ______ False ______ *Code* section ____________

B. Protective guard strips are required for Romex and NM cable within 7 feet of the nearest edges of an accessible attic entrance; however, where the space is not accessible by permanent stairs or ladders, the guard strips shall be within __________ feet of the attic entrance.

Code section ____________

Assignment Sheet 6

C. Intermediate metal conduit is not acceptable as an equipment grounding conductor.

True ______ False ______ *Code* section ____________

D. Aluminum fittings and enclosures are permitted on steel rigid metal conduit runs.

True ______ False ______ *Code* section ____________

E. Rigid metallic conduit threads are to be tapered at ¾ inch per foot.

True ______ False ______ *Code* section ____________

F. Rigid nonmetallic conduit sizes ½ inch to 1 inch are to be supported at 3-foot intervals.

True ______ False ______ *Code* section ____________

G. Electrical metallic tubing (EMT) conduit shall not be threaded.

True ______ False ______ *Code* section ____________

H. Flexible metallic tubing runs shall not be over 6 feet long.

True ______ False ______ *Code* section ____________

I. Three-eights-inch flexible metal conduit runs are limited to 6 feet in length as part of a listed assembly.

True ______ False ______ *Code* section ____________

J. A busway is considered to be a grounded metal enclosure containing factory-mounted bare or insulated conductors.

True ______ False ______ *Code* section ____________

Part 3

Directions: Use the *National Electrical Code*, Articles 430 through 501, to find the following information. Write the correct answers in the appropriate blanks.

A. In marking motors, the nameplate is to show both rated volts and full-load amperes; for multispeed motors, the nameplate is to show full-load amperage for each speed, except shaded-pole and permanent-split capacitor motors where amperage is required only for maximum speed.

True ______ False ______ *Code* section ____________

Assignment Sheet 6

B. The circuit of a control apparatus that carries the electric signals directing the performance of the controller, but does not carry the main power current, is called a

_________________ _________________ _________________.

Code section ___________

C. The disconnecting means for a torque motor shall have an ampere rating of at least 125 percent of the motor nameplate current.

True _____ False _____ *Code* section ___________

D. The branch circuit for an air conditioner compressor unit may have a short circuit protection device rated no greater than 225 percent of the motor rated-load, current or branch-circuit selection current, whichever is greater.

True _____ False _____ *Code* section ___________

E. The ampacity of generator phase wires to the first overcurrent device shall not be less than 125 percent of the nameplate current rating.

True _____ False _____ *Code* section ___________

F. Water pipes intended for vault fire protection or transformer cooling are permitted in a transformer vault.

True _____ False _____ *Code* section ___________

G. A sealed cell or battery may have a vent opening but no opening to add battery fluid.

True _____ False _____ *Code* section ___________

H. Class I hazardous locations are those having to do with hazardous gases or vapors.

True _____ False _____ *Code* section ___________

I. Conduit seals in Class I, Division 1 hazardous locations may be 24 inches from an enclosure for switching.

True _____ False _____ *Code* section ___________

Assignment Sheet 6

Part 4

Directions: Use the *National Electrical Code* to find the following information. Answers may be found throughout the *Code*.

A. Generally, service entrance conductors shall not be spliced. How many exceptions to this rule are permitted?

Number ____________ *Code* section ____________

B. A #18 fixture wire is considered to be protected by a 200-ampere breaker.

True ______ False ______ *Code* section ____________

C. "Conduit bodies shall not contain splices, taps, or devices unless they are durably and legibly marked by the manufacturer with their cubic inch capacity."

True ______ False ______ *Code* section ____________

D. "All pull boxes, junction boxes, conduit bodies, and fittings shall be provided with __________________ compatible with the box."

Code section ____________

E. "The allowable ampacities in Tables 310-16 through 310-19 shall be limited to those permitted for the adjacent insulated conductors where bare conductors are used with insulated conductors."

True ______ False ______ *Code* section ____________

F. Type NM or NMC cable "shall comply with *Code* section ______ where installed through or parallel to joists, studs, rafters, or similar wood or metal members."

Code section ____________

G. Capacitors 600 volts nominal and under shall be provided with a means of draining the stored charge to 50 volts or less within __________________ __________________ after being disconnected from power source.

Code section ____________

H. Hazardous locations Class II, Group E are those that are hazardous because of the presence of combustible metal dust.

True ______ False ______ *Code* section ____________

I. "All 120-volt receptacles located within 25 feet of the inside walls of a pool shall be protected by a ground-fault circuit-interrupter."

True ______ False ______ *Code* section ____________

Basic Equipment
Unit 7

Objective Sheet

Unit Objective

After completing this unit, the student should be able to identify and install electrical boxes and enclosures used in the electrical field. The student should demonstrate these competencies by completing the assignment and job sheets, and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to basic equipment with their correct definitions.
2. Identify classes of outlet boxes used in electrical wiring.
3. List information needed to calculate boxfill.
4. Match types of enclosures with their conditions for use.
5. State the purposes of controller enclosures.
6. Label types of devices commonly used in electrical wiring.
7. Label types of covers and plates used in electrical wiring.
8. Identify supports and anchors commonly used in electrical wiring.
9. Identify screws, bolts, and nuts commonly used in electrical wiring.
10. Identify classes of box mounting devices for steel structures.
11. Determine the correct number of conductors for boxfill. (Assignment Sheet 1)
12. Install outlet boxes on wood studs on a framed wall. (Job Sheet 1)
13. Install outlet boxes on steel structures and rods using caddy clips. (Job Sheet 2)
14. Install outlet boxes on steel studs using caddy metal stud clips for switch boxes. (Job Sheet 3)
15. Install masonry boxes in a block wall. (Job Sheet 4)

Basic Equipment
Unit 7

Suggested Activities

Instructional Plan

Preparation

1. Read the unit carefully and plan for instruction. Study the specific objectives to determine the order in which you will present them.

2. Review Teaching Suggestions section that follows. Plan for classroom activities.

3. Plan your presentation to take advantage of student learning styles and to accommodate special needs students.

4. Make transparency from the transparency master included with this unit. The master appears in the teacher guide only and is intended to be used with the following objective:

   TM 1 and 2—Box Design Features (Objective 2)

5. Obtain films, videotapes, and other resources to supplement instruction of this unit. See ordering information in the Suggested Supplemental Resources section that follows.

6. Develop teaching plan. Adjust for different learning styles.

7. Devise additional job sheets for applications based on the wiring methods in your locality.

8. Make copies of Unit Evaluation Form.

Delivery and Application

9. Provide students with unit of instruction.

10. Discuss unit and specific objectives.

11. Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic skills when applicable.

12. Discuss the assignment sheet and schedule due date. Review criteria for assignment sheet evaluation.

13. Discuss and demonstrate the job sheets. Review the evaluation criteria for each. Schedule performance dates.

Suggested Activities

Evaluation

14. Discuss the use of the Unit Evaluation Form with students. Select and discuss the rating scale that will be used for student evaluation.

15. Make copies of the written test. Add or modify test items as needed.

16. Give written test.

17. Compile assignment and job sheet ratings and written test scores on the Unit Evaluation Form. Include any additional assignments.

18. Reteach and retest as required.

Teaching Suggestions

Note: Skill areas appearing in boldface type in the Teaching Suggestions refer to the academic and workplace skills identified by the American Society for Training and Development (ASTD) and the U.S. Department of Labor. These have been adapted by MAVCC.

1. Discuss slang terms and regional terms associated with basic equipment. Devise a short quiz to determine whether students can make the proper connections between the slang and industry terms. Skill areas: **Oral communications, writing, problem solving**

2. Show examples of outlet boxes and electrical devices to the class.

Resources Used in Developing This Unit

1. Adams, James E. and Gordon Rockmaker. *Industrial Electricity Principles and Practices*, Third Edition. New York: McGraw-Hill Book Co., 1985.

2. Early, Mark W., John M. Caloggero, and Richard H. Murray. *National Electrical Code, 1993*. Quincy, MA: National Fire Protection Association, 1992.

3. Taylor, Mark. *Residential Wiring*. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1983.

4. Teague, Cash and Garner Pewewardy. *Industrial Electricity: In-Plant Distribution*. Stillwater, OK: Oklahoma Curriculum and Instructional Materials Center, 1984.

Suggested Activities

Suggested Supplemental Resources

Catalogs

1. *Holub Catalog No. 23*, ITT Holub Industries, Sycamore, Illinois.
2. *Roco Steel Box Catalog No. B-774*, Roco Inc., South Bend, Indiana.
3. *Leviton Catalog D-100*, Leviton Manufacturing Co., Brooklyn, New York.
4. *Rigid Tool Catalog*, 400 Clark Street, Elyria, OH 44036.

Instructions for Evaluating Student Performance

Assignment Sheets—Be sure the student understands the criteria on which the evaluation is based. Assign a point value to each criterion and convert the total points to a percentage for grading.

Job Sheets—Be sure the student understands the criteria on which the evaluation is based. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in either the teacher edition or student manual. Then observe the student performing the procedure. Rate both process and product.

> Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily achieved the step(s) for each checkpoint area. If the student is unable to correctly complete the procedure, have the student review the materials and try again.
>
> Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria which have been provided as part of the job sheet. Complete the rating by assigning a point value to each criterion and by converting the point total to a percentage for grading. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Suggested Activities

Sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) which best fits your program needs.

Option A

4 - Skilled—Can perform job with no additional training.
3 - Moderately skilled—Has performed job during training program; limited additional training may be required.
2 - Limited skill—Has performed job during training program; additional training is required to develop skill.
1 - Unskilled—Is familiar with process, but is unable to perform job.

Option B

Yes—Can perform job with no additional training.

No—Is unable to perform job satisfactorily.

Basic Equipment
Unit 7

Answers to Assignment Sheet 1

A.	7
B.	7
C.	1
D.	3
E.	10
F.	4
G.	4
H.	6
I.	3
J.	5

Basic Equipment
Unit 7

Answers to Written Test

1. a. 8
   b. 12
   c. 5
   d. 13
   e. 6
   f. 11
   g. 2
   h. 1
   i. 4
   j. 7
   k. 10
   l. 3
   m. 9

2. a. Square boxes
   b. Octagon boxes
   c. Outlet boxes (device boxes)
      (1) Switch boxes
      (2) Handy boxes
   d. Masonry boxes
      (1) Regular masonry boxes
      (2) Masonry through-the-wall boxes

3. a. Cubic inches of box
   b. Size of wire
   c. Number of yoke- or strap-holding devices and grounds

4. a. 1
   b. 4
   c. 2
   d. 3
   e. 5
   f. 6

5. a. Keeping boxes and enclosures clean
   b. Keeping boxes and enclosures dry
   c. Protecting boxes and enclosures from accidental contact
   d. Preventing injuries

6. a. Combination devices
   b. Sockets
   c. Switches
   d. Receptacles

7. a. Wall plates
   b. Square covers
   c. Exposed work raised square covers
   d. Handy box covers
   e. Round covers

Answers to Written Test

8. a. Bar hanger
   b. Switch box supports
   c. One-hole strap
   d. Two-hole strap
   e. Plastic anchors
   f. Lead anchor
   g. Toggle bolt
   h. Molly bolt
   i. Drive stud

9. a. Sheet metal screw
   b. Self-drilling screw
   c. Wood screw
   d. Machine screw
   e. Setscrew
   f. Hex-socket-head bolt
   g. Carriage bolt
   h. Hex-head bolt
   i. Acorn nut
   j. Spring nut
   k. Wing nut
   l. Fixture nut
   m. Single-thread nut
   n. Plain hex nut

10. a. Acoustical tee-bar clips
    b. Acoustical tee-bar electrical box hanger and mounting clip
    c. Metal stud clips for switch boxes
    d. MF clips for switch boxes
    e. Conduit box clip

Basic Equipment
Unit 7

Written Test

Name ______________________________ Score ____________

1. Match terms related to basic electrical equipment with their correct definitions. Write the correct numbers in the blanks. Definitions are continued on the next page.

______a. Enclosures designed for conduit or cable entrances to enclose the conductor splices and taps

______b. So constructed, protected, or treated as to prevent rain from interfering with successful operation

______c. So constructed that dust will not enter the enclosing case

______d. So constructed or protected that exposure to a beating rain will not result in the entrance of water

______e. Capable of containing hot explosive flames within the enclosure to prevent explosions in the surrounding atmosphere

______f. Electrical boxes designed for the mounting of receptacles, switches, light fixtures, or other devices

______g. Enclosure designed either for surface or flush mounting; provided with a frame, mat, or trim in which a swinging door or doors may be hung

______h. Number of conductors of a certain size permitted in a box; number is based on cubic inches of box

______i. So constructed or protected that dust will not interfere with successful operation

1. Boxfill
2. Cabinet
3. Disconnecting means
4. Dustproof
5. Dusttight
6. Explosion-proof
7. Joint Industry Conference (JIC) boxes
8. Junction boxes
9. Knockout (KO)
10. NEMA enclosures
11. Outlet boxes
12. Rainproof
13. Raintight

Written Test

______j. Boxes or enclosures made to set standards for such uses as junction boxes and housing terminal blocks

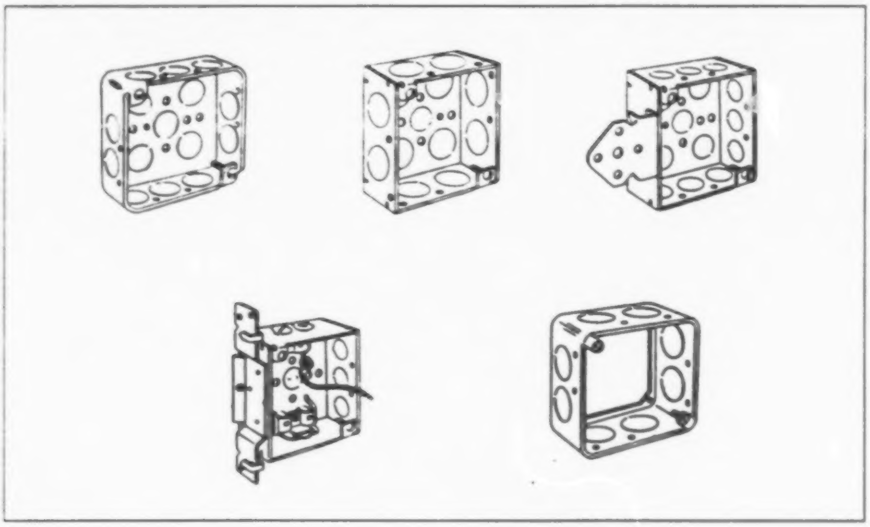
______k. Electrical enclosures specifically designed to standards for use in specific locations and for various conditions such as indoor, outdoor, dusty, corrosive, wet, and explosive conditions

______l. Device, or group of devices, or other means by which circuit conductors can be disconnected from their source of supply

______m. Partially cut out piece of metal or plastic that can be forced out when a hole is needed

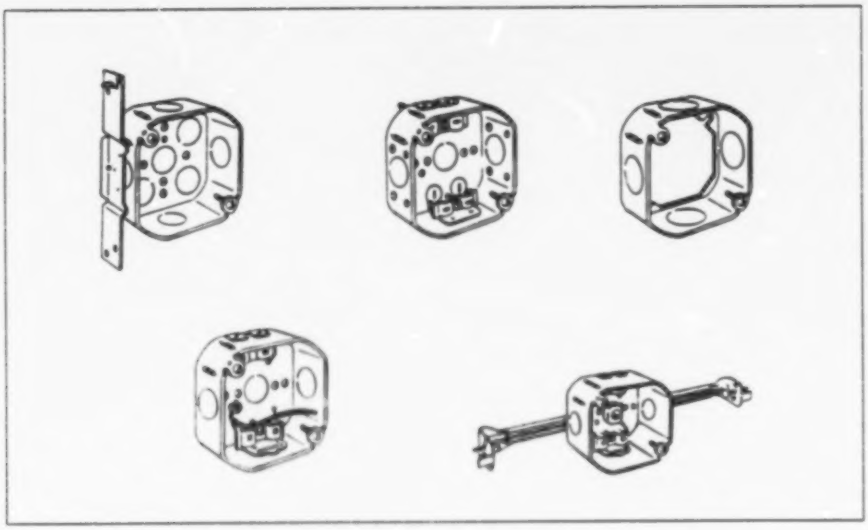
2. Identify the following classes of outlet boxes used in electrical wiring. Write the correct names in the blanks.

Octagon boxes	Switch boxes
Regular masonry boxes	Masonry through-the-wall boxes
Handy boxes	Square boxes



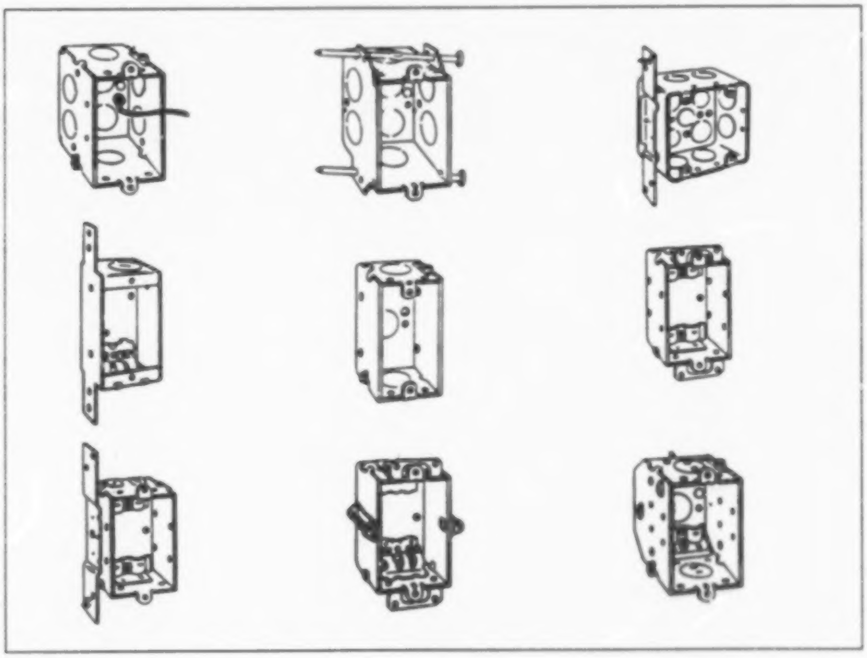
a. ____

Written Test

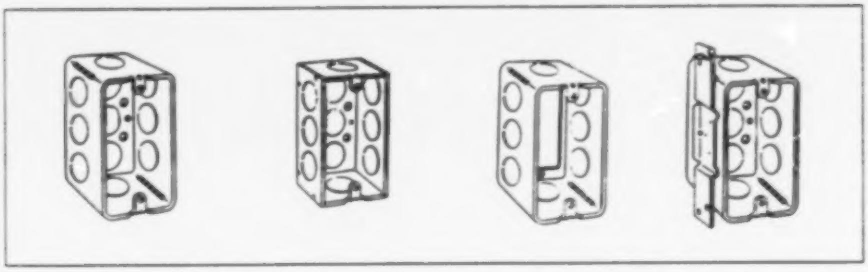


b. ____________________

c. Outlet boxes (device boxes)

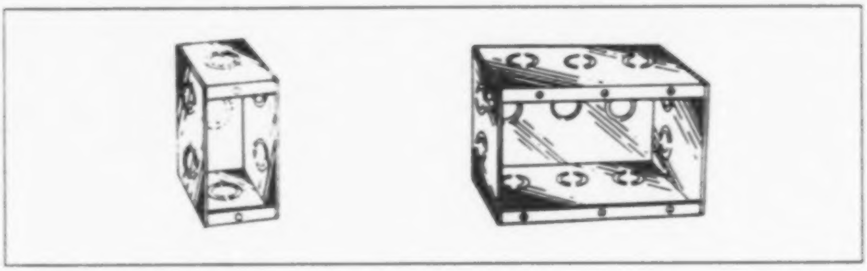


(1) ____________________

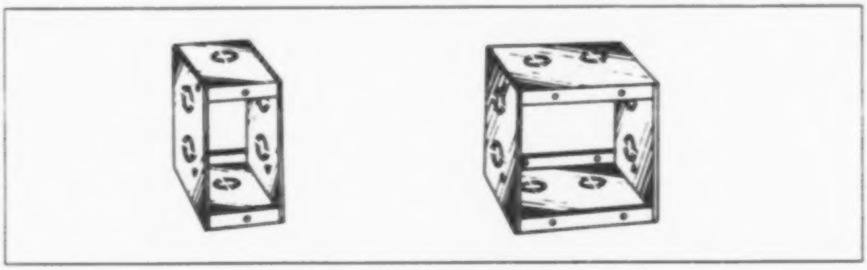


(2) ______________________________

d. Masonry boxes



(1) ______________________________



(2) ______________________________

3. List information needed to calculate boxfill.

a. ______________________________

b. ______________________________

c. ______________________________

Written Test

4. Match types of enclosures with their conditions for use. Write the correct numbers in the blanks.

______a. For use where rain or dust could interfere with normal operation

______b. For use in hazardous locations

______c. For normal use in locations without excessive dust, moisture, or corrosive atmospheres

______d. For use in locations having corrosive atmospheres

______e. For use where dust could interfere with normal operation

______f. For use in wet locations

1. Weatherproof
2. General duty
3. Corrosionproof
4. Explosionproof
5. Dustproof
6. Watertight

5. State the purposes of controller enclosures.

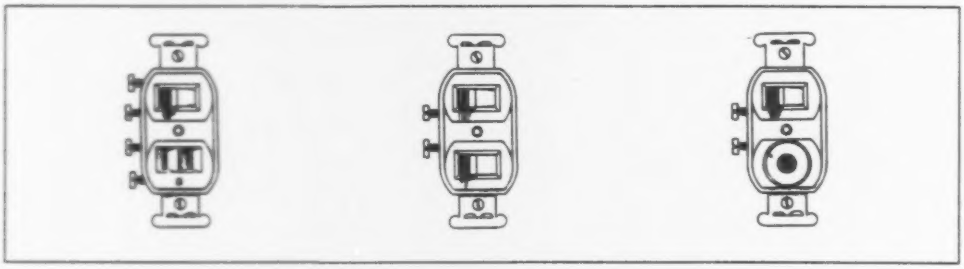
a. ______________________________

b. ______________________________

c. ______________________________

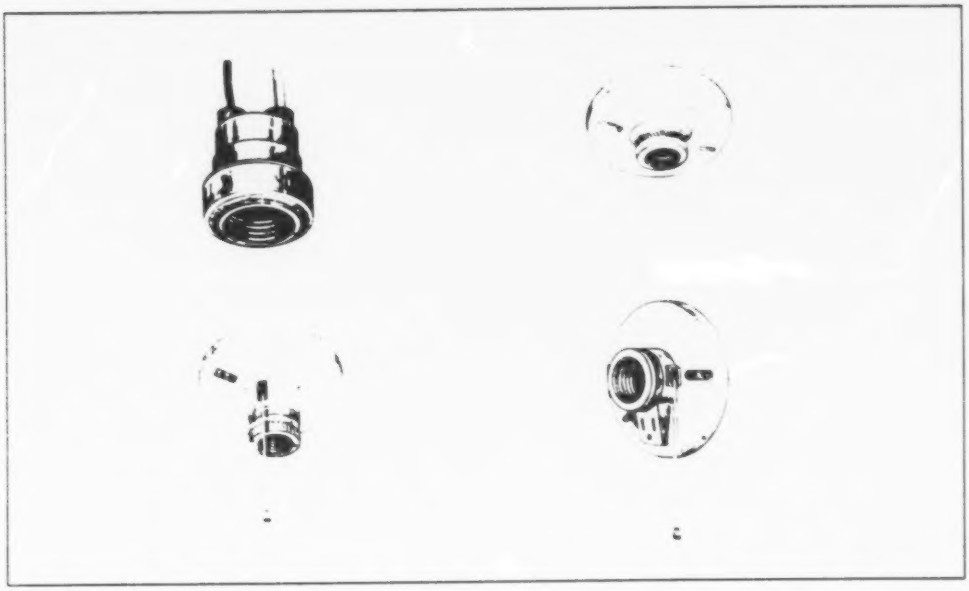
d. ______________________________

6. Label the following types of devices commonly used in electrical wiring.

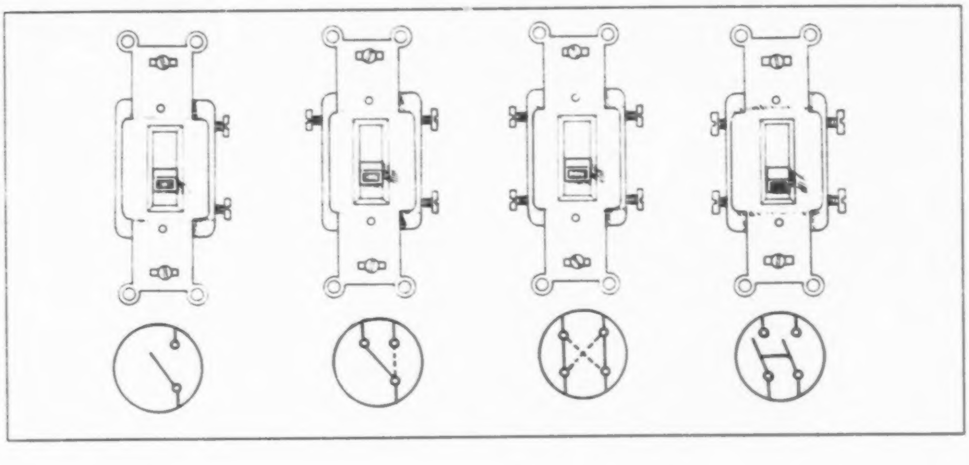


a. ______________________________

Written Test

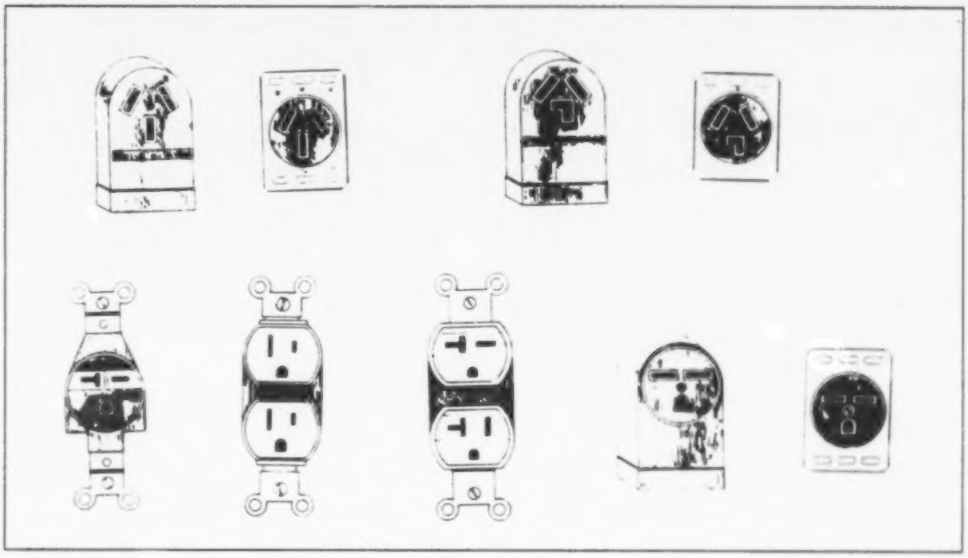


b. ____



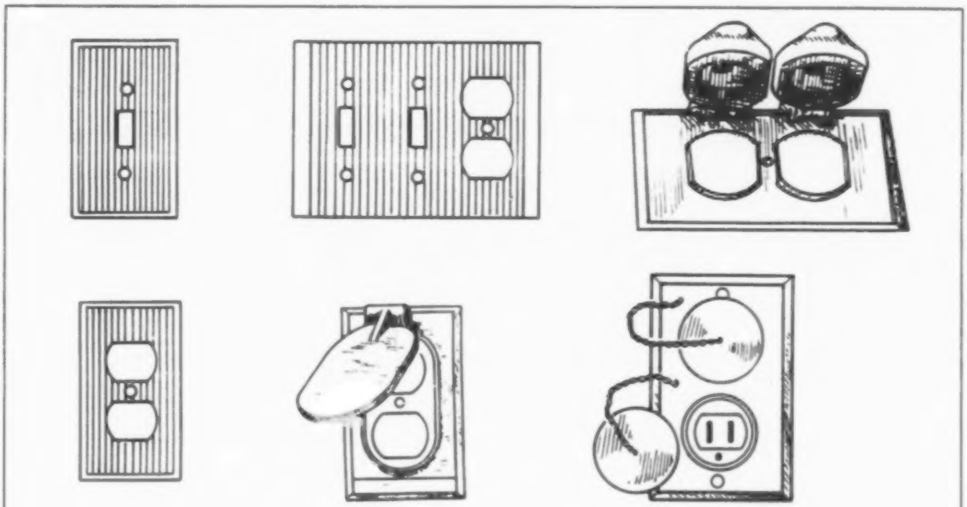
c. ____

Written Test



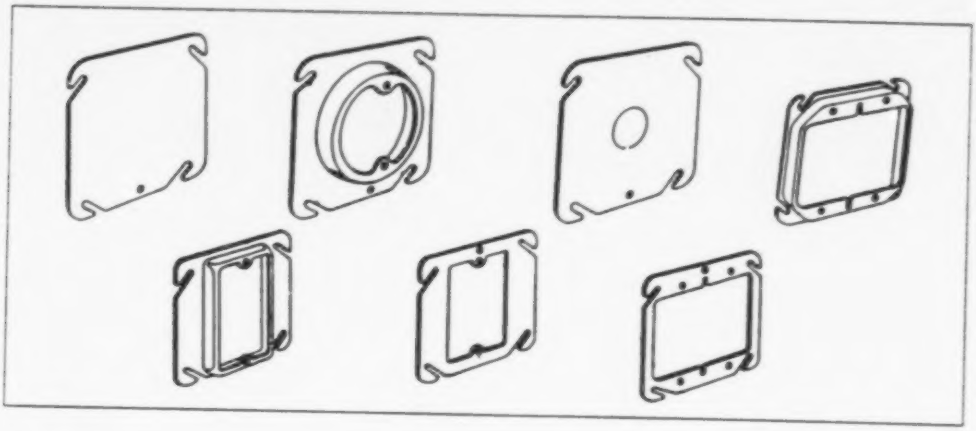
d. ______________________________

7. Label the following types of covers and plates used in electrical wiring.

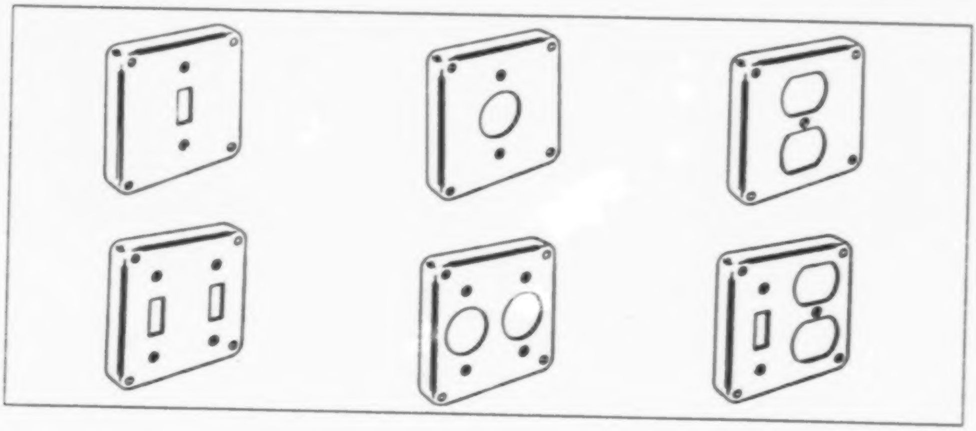


a. ______________________________

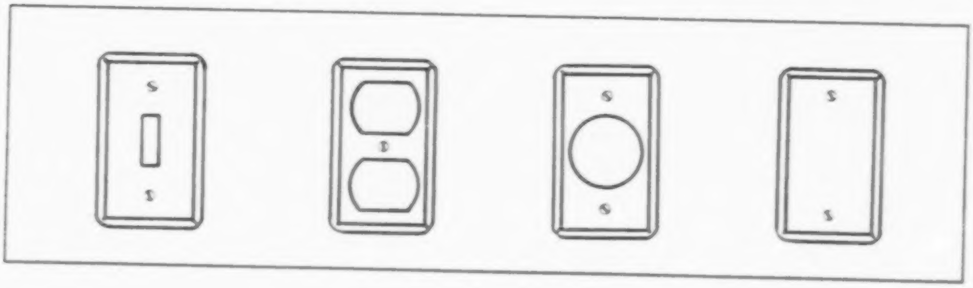
Written Test



b. ______________________________

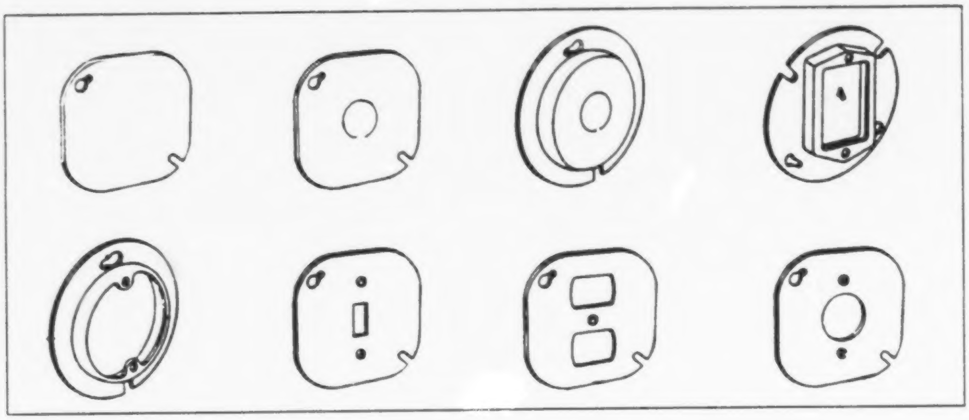


c. ______________________________



d. ______________________________

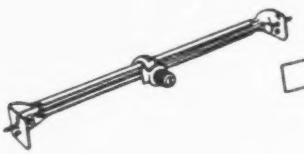
Written Test



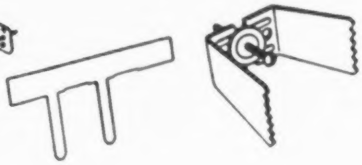
e. ____

8. Identify the following supports and anchors commonly used in electrical wiring. Write the correct names in the blanks.

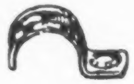
Molly bolt
Switch-box supports
Two-hole strap
Bar hanger
Drive stud
One-hole strap
Lead anchor
Plastic anchors
Toggle bolt



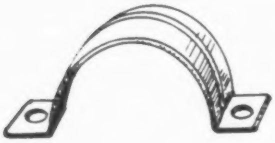
a. ____________________



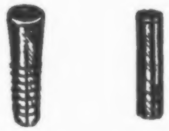
b. ____________________



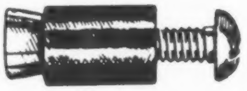
c. ____________________



d. ____________________

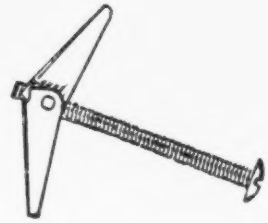


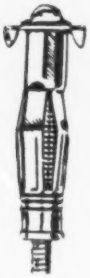
e. ____________________

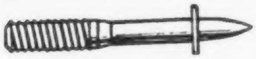


f. ____________________

Written Test







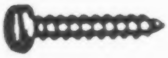
g. ________________ h. ________________ i. ________________

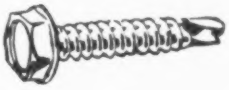
9. Identify the following screws, bolts, and nuts commonly used in electrical wiring. Write the correct names in the blanks.

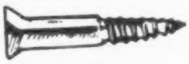
Setscrew
Woodscrew
Spring nut
Wing nut
Machine screw

Single-thread nut
Sheet metal screw
Self-drilling screw
Hex-head bolt
Plain hex nut

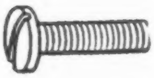
Fixture nut
Hex-socket-head bolt
Carriage bolt
Acorn nut

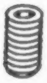


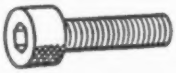




a. ________________ b. ________________ c. ________________

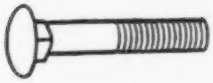




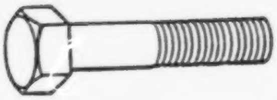


d. ________________ e. ________________ f. ________________

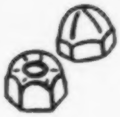
Written Test



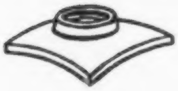
g. ____________________



h. ____________________



i. ____________________



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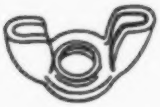

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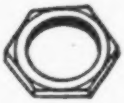

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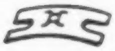

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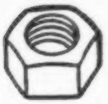
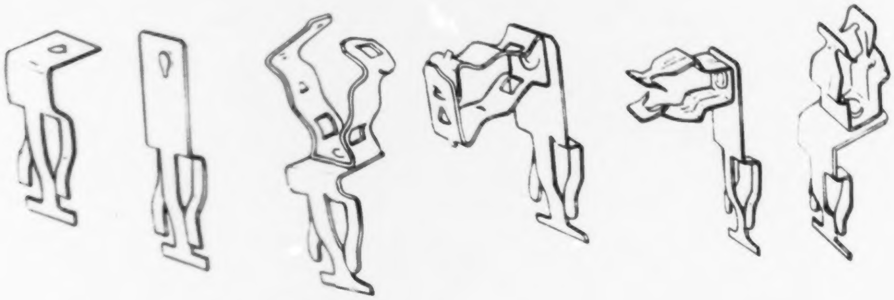


n. ____________________

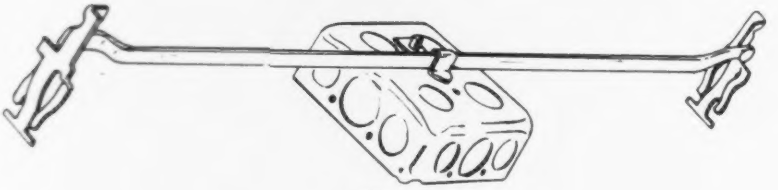
Written Test

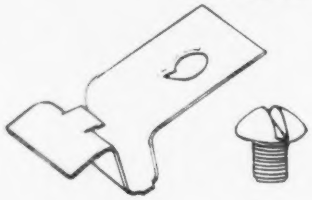
10. Identify the following classes of box-mounting devices for steel structures. Write the correct names in the blanks.

Acoustical tee-bar electrical box hanger and mounting clip	Conduit box clip
MF clip for switch boxes	Metal stud clips for switch boxes
	Acoustical tee-bar clips



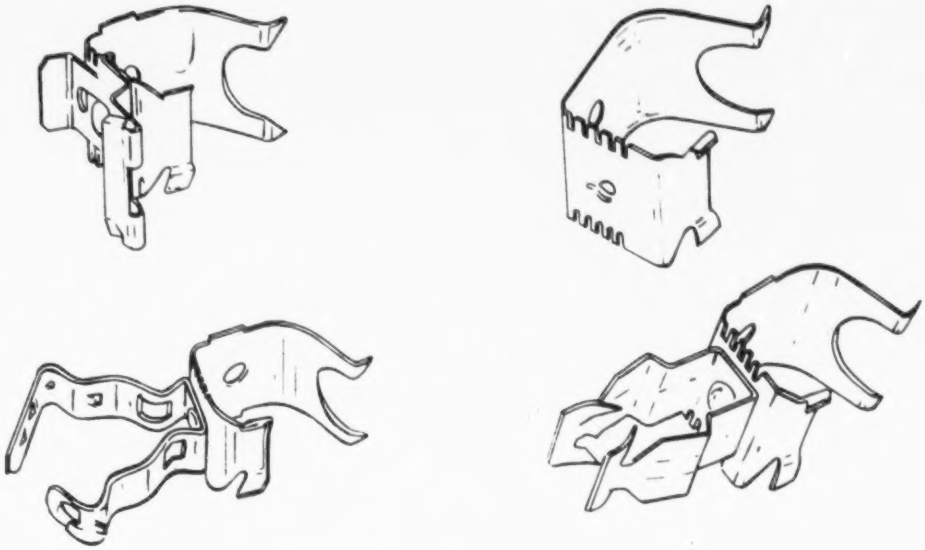
a. ______________________________





b. ______________________________

Written Test



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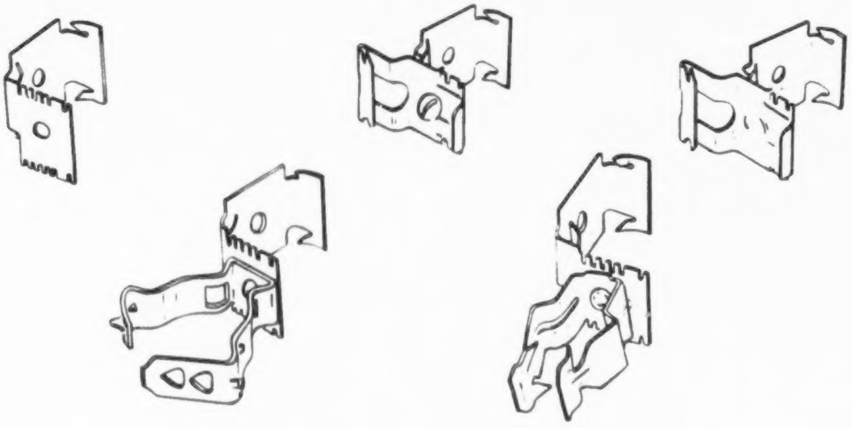

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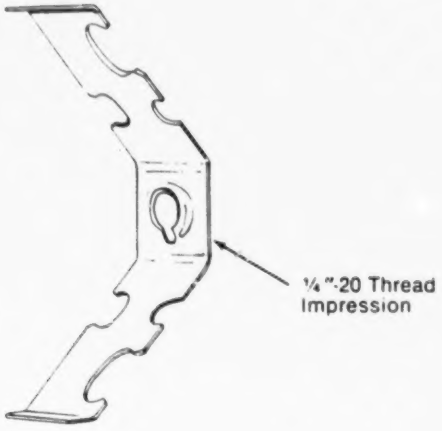
Written Test


¼"-20 Thread
Impression

e. ____

*Permission to duplicate this test is granted.

Basic Equipment
Unit 7

Unit Evaluation Form

Student Name ______________________________ Unit Rating __________

Assignment Sheet 1—Determine the Correct Number of Conductors for Boxfill Rating ______

Comments: ____

____

Job Sheet 1—Install Outlet Boxes on Wood Studs on a Framed Wall Rating ______

Comments: ____

____

Job Sheet 2—Install Outlet Boxes on Steel Structures and Rods Using Caddy Clips Rating ______

Comments: ____

____

Job Sheet 3—Install Outlet Boxes on Steel Studs Using Caddy Metal Stud Clips for Switch Boxes Rating ______

Comments: ____

____

Job Sheet 4—Install Masonry Boxes in a Block Wall Rating ______

Comments: ____

____

Written Test Scores

Pretest ______ Posttest ______ Other ______

Other ____

____

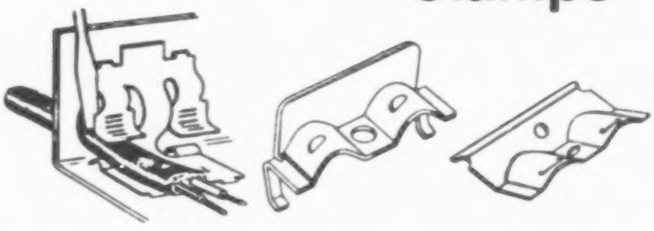
Teacher Signature ______________________________ Date __________

Student Signature ______________________________ Date __________

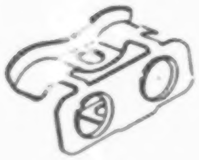
***Permission to duplicate this form is granted.**

Box Design Features

Clamps

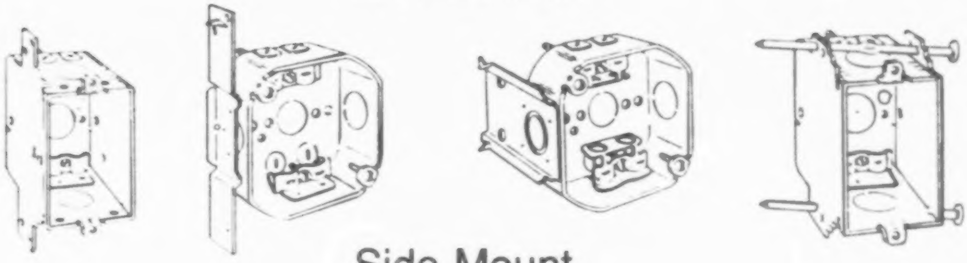


Nonmetallic
Cable Clamps

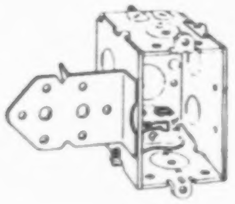


Metallic
Cable Clamp

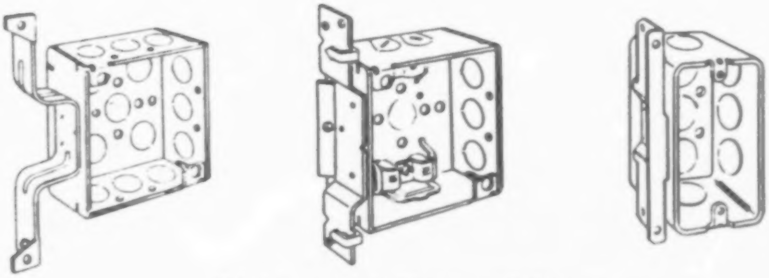
Brackets



Side Mount



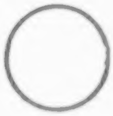
Front
Mount

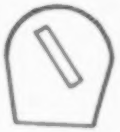


Side and Front Mount

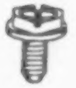
Box Design Features (Continued)

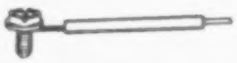
Box Openings

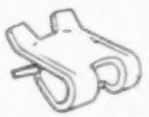

Knockout


Pry-Out

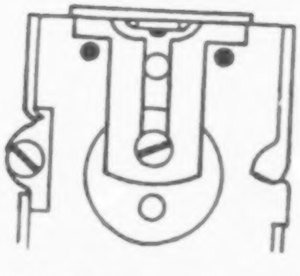
Grounding Equipment

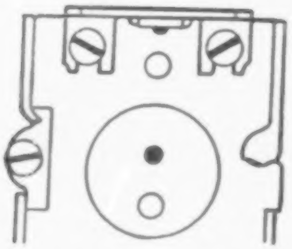

Screw


Screw with Pigtail


Clip

Plaster Ears


One-Screw Design


Two-Screw Design

Basic Equipment
Unit 7

Information Sheet

1. **Terms and definitions**

   a. **Boxfill** — Number of conductors of a certain size permitted in a box; number is based on cubic inches of box

   b. **Cabinet** — Enclosure designed either for surface or flush mounting; provided with a frame, mat, or trim in which a swinging door or doors may be hung

   c. **Disconnecting means** — Device, or group of devices, or other means by which circuit conductors can be disconnected from their source of supply

   d. **Dustproof** — So constructed or protected that dust will not interfere with successful operation

   e. **Dusttight** — So constructed that dust will not enter the enclosing case

   f. **Explosionproof** — Capable of containing hot explosive flames within the enclosure to prevent explosions in the surrounding atmosphere

   g. **Joint Industry Conference (JIC) boxes** — Boxes or enclosures made to Joint Industry Conference standards for such uses as junction boxes and housing terminal blocks

   h. **Junction boxes** — Enclosures designed for conduit or cable entrances to enclose the conductor splices and taps

   i. **Knockout (KO)** — Partially cut out piece of metal or plastic that can be forced out when a hole is needed

   j. **NEMA enclosures** — Electrical enclosures specifically designed to standards for use in specific locations and for various conditions such as indoor, outdoor, dusty, corrosive, wet, and explosive conditions

   k. **Outlet boxes** — Electrical boxes designed for the mounting of receptacles, switches, light fixtures, or other devices

   l. **Rainproof** — So constructed, protected, or treated as to prevent rain from interfering with successful operation

   m. **Raintight** — So constructed or protected that exposure to a beating rain will not result in the entrance of water

Information Sheet

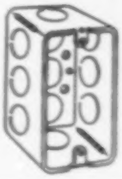
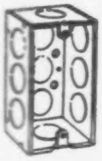
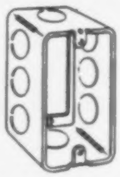
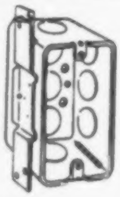
2. **Classes of outlet boxes used in electrical wiring (NEC Article 370)**

   a. Outlet boxes (device boxes) (Figures 1 and 2)

   Note: Most boxes can be purchased in metal or in a nonmetallic composition such as fiber, plastic, nylon, or rubber.

   - Handy boxes

   Figure 1

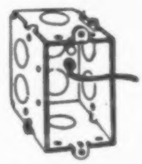
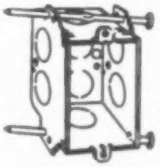
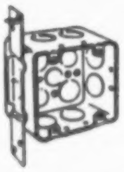
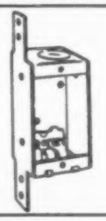
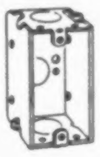
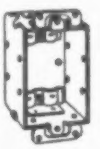
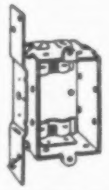
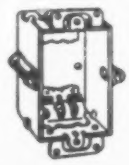
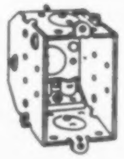
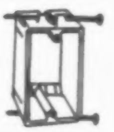
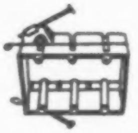
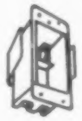
One-Piece Molded Construction	One-Piece Welded Construction	Extension	Box with Bracket
			

Information Sheet

- Switch boxes

  Note: Switch boxes are available in steel, plastic, and Bakelite®.

  Figure 2

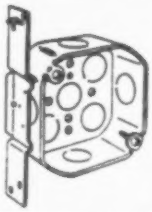
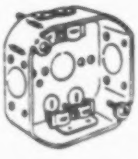
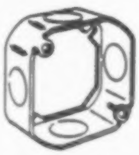
Gangable with Grounding Pigtail	**Nail-On**	**Solid Two-Gang Bracket**
		
Nongangable Bracket with Cable Clamps	**Gangable with Nail Holes**	**Gangable with Ears and Cable Clamps**
		
Gangable Bracket with Cable Clamps	**Box with Drywall Grips, Cable Clamps, and Ears**	**Beveled Corner with Clamps and Ears**
		
Single Gang Fiber Nail-Up	**Three-Gang Fiber Nail-Up**	**Single Gang Fiber Cut-In Box**
		

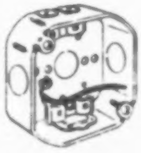
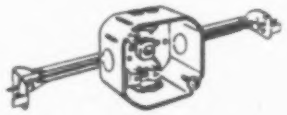
Information Sheet

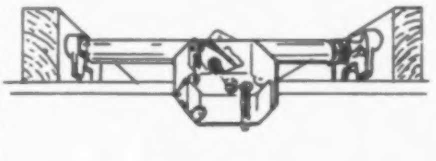
b. Octagon boxes (Figure 3)

Note: Octagon boxes, like switch boxes, can be either metallic or nonmetallic; like switch boxes, they can be purchased in many different depths.

Figure 3

Box with Bracket	Box with Cable Clamps and Nail Holes	Extension
		

Box with Cable Clamps and Grounding Pigtail	Box with Bar Hanger and Cable Clamps
	

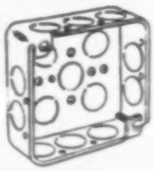
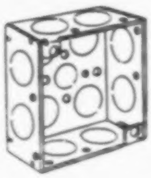
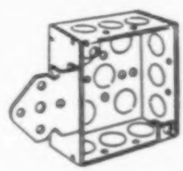
Fan Hanger Box


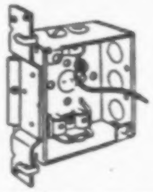
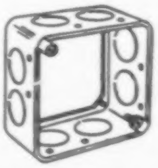
Information Sheet

c. Square boxes (Figure 4)

Note: Square boxes are used in conjunction with covers designed for special purposes.

Figure 4

One-Piece Molded Construction	**One-Piece Welded Construction**	**Box with Bracket**
		

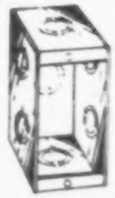
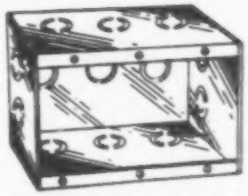
Box with Bracket, Cable Clamps, and Grounding Pigtail	**Extension**
	

d. Masonry boxes (Figures 5 and 6)

Note: Masonry boxes have square corners that are easier to cut and save installation time. The boxes are deep so that conduit will position in the voids.

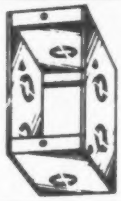
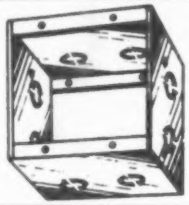
- Regular masonry boxes

Figure 5

Single-Gang	**Three-Gang**
	

- Masonry through-the-wall boxes

Figure 6

Single-Gang	Two-Gang
	

3. **Information needed to calculate boxfill**

   a. Cubic inches of box

   Note: Multiplying width times height times depth gives cubic inches.

   b. Size of wire

   c. Number of yoke- or strap-holding devices and grounds

4. **Types of enclosures and their conditions for use**

   a. **General duty** — For normal use in locations without excessive dust, moisture, or corrosive atmospheres

   b. **Dustproof** — For use where dust could interfere with normal operation

   Examples: Feed mill, cement plant

   c. **Weatherproof** — For use where rain or dust could interfere with normal operation

   Example: Irrigation motor controller

   d. **Watertight** — For use in wet locations

   Examples: Milk plant, mines

   e. **Corrosionproof** — For use in locations having corrosive atmospheres (*NEC* Article 300-6)

   Examples: Galvanizing plant, fertilizer plant

   f. **Explosionproof** — For use in hazardous locations (*NEC* Article 500)

   Examples: Grain elevators, oil refineries, chemical plants

Information Sheet

5. **Purposes of controller enclosures**

   a. Keeping boxes and enclosures clean

   Note: Relays and contactors should be cleaned periodically to ensure continued operation.

   b. Keeping boxes and enclosures dry

   Note: Moisture is one of the greatest enemies of electrical insulation. Moisture due to condensation may collect inside a sealed enclosure. Heaters are often used to correct this condition.

   c. Protecting boxes and enclosures from accidental contact

   Caution: Never bring metal or other objects into contact with live parts.

   d. Preventing injuries

   Caution: To avoid personal injury, protective covers must be in place when system is in operation.

Information Sheet

6. Types of devices commonly used in electrical wiring (Figures 7-10)

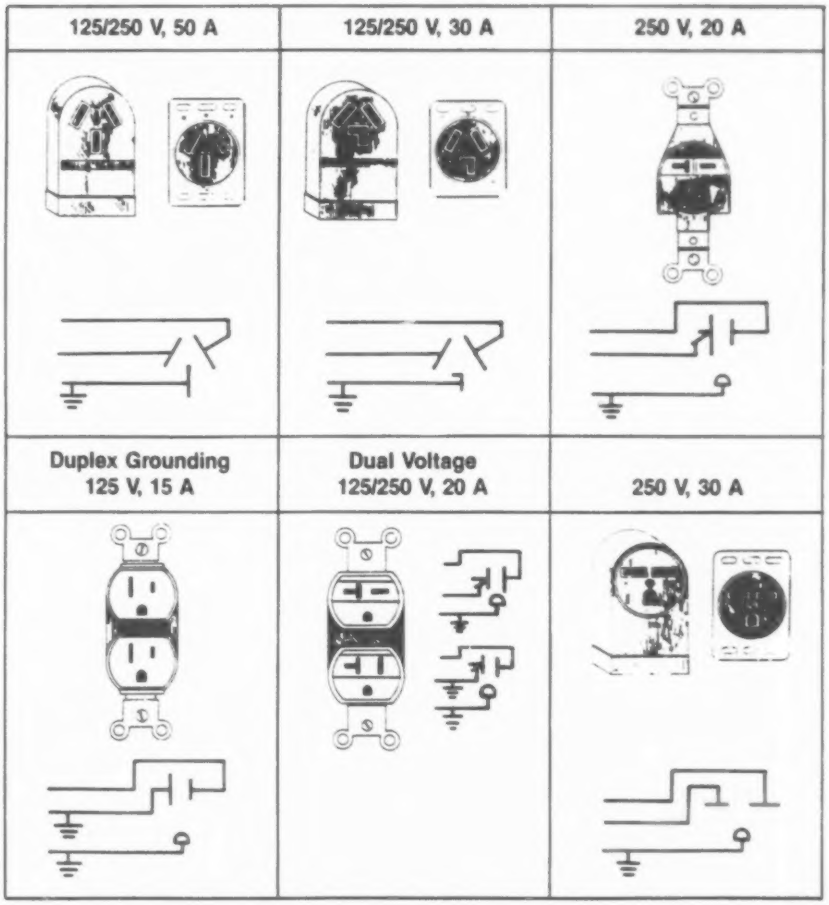
Note: Manufacturers make different grades of devices. Price and quality vary with the grades. Specification grade is the most expensive. Before installing devices, check the grade requested in the job bid.

a Receptacles

Note: *NEC* Articles 250-74, 410-58, and 501-12 deal with specific installation of receptacles.

Example: "410-58(a). Grounding-type receptacles, cord connectors, and attachment plugs shall be provided with one fixed grounding pole in addition to the circuit poles."

Figure 7


125/250 V, 50 A
125/250 V, 30 A
250 V, 20 A
Duplex Grounding
125 V, 15 A
Dual Voltage
125/250 V, 20 A
250 V, 30 A

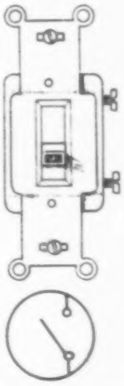
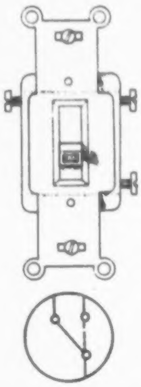
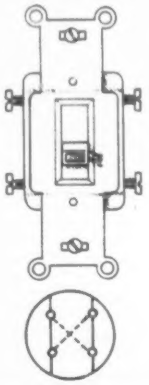
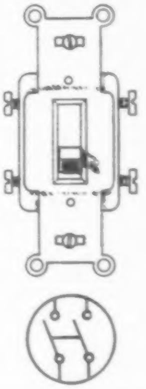
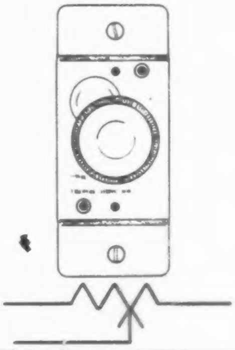
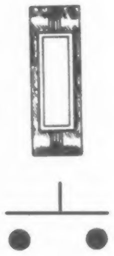
Information Sheet

b. Switches

Note: Article 380 of the *NEC* covers switches.

Example: "380-2. Three-way and four-way switches shall be so wired that all switching is done only in the ungrounded circuit conductor. Where in metal raceways or metal-jacketed cables, wiring between switches and outlets shall be in accordance with Section 300-20(a)."

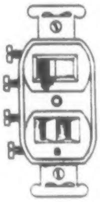
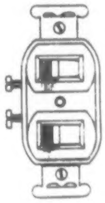
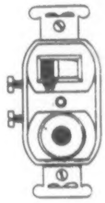
Figure 8

Single Pole	**Three-Way**	**Four-Way**
		
Double Pole	**Dimmer**	**Low-Voltage Push Button**
		

Information Sheet

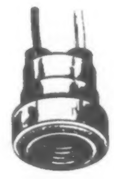
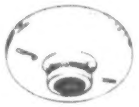
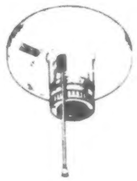
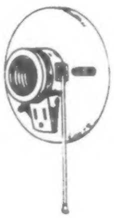
c. Combination devices

Figure 9

Switch and Receptacle	Two Switches	Switch and Pilot Light
		

d. Sockets

Figure 10

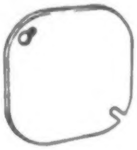
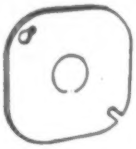
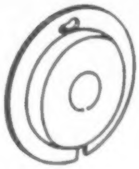
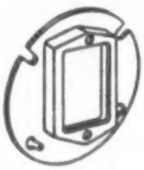
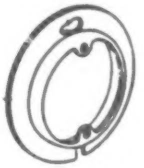
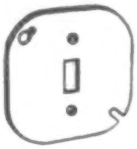
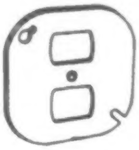
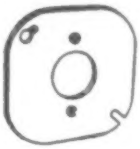
Keyless Pigtail	Keyless Cover
	
Pull-Chain Cover	**Pull-Chain Cover with Grounding-Type Receptacle**
	

Information Sheet

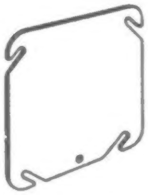
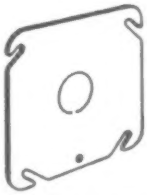
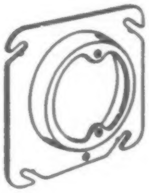
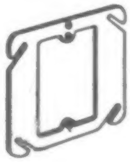
7. **Types of covers and plates used in electrical wiring** (Figures 11-15)

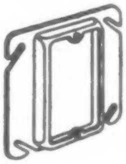
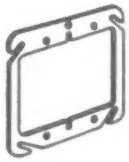
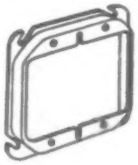
a. Round covers

Figure 11

Flat Blank	**Flat Blank with Knockout**	**Raised with Knockout**	**Raised for Single Device**
			
Raised Open	**Flat Toggle**	**Flat Duplex Receptacle**	**Flat Single Receptacle**
			

b. Square covers

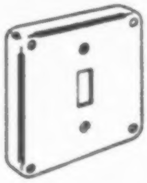
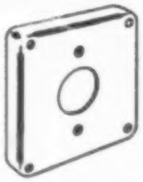
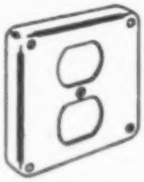
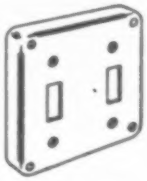
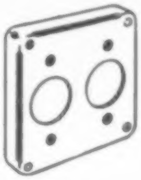
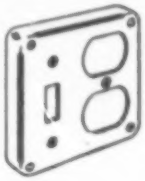
Flat Blank	**Flat Blank with Knockout**	**Raised Open**	**Flat for Single Device**
			

Raised for Single Device	**Flat for Two Devices**	**Raised for Two Devices**
		

Information Sheet

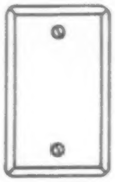
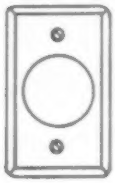
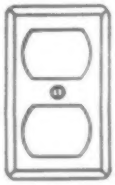
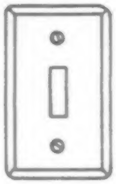
c. Exposed work raised square covers

Figure 13

Single Toggle	Single Receptacle	Duplex Receptacle
		
Two-Toggle	Two-Receptacle	Toggle and Duplex Receptacle
		

d. Handy box covers

Figure 14

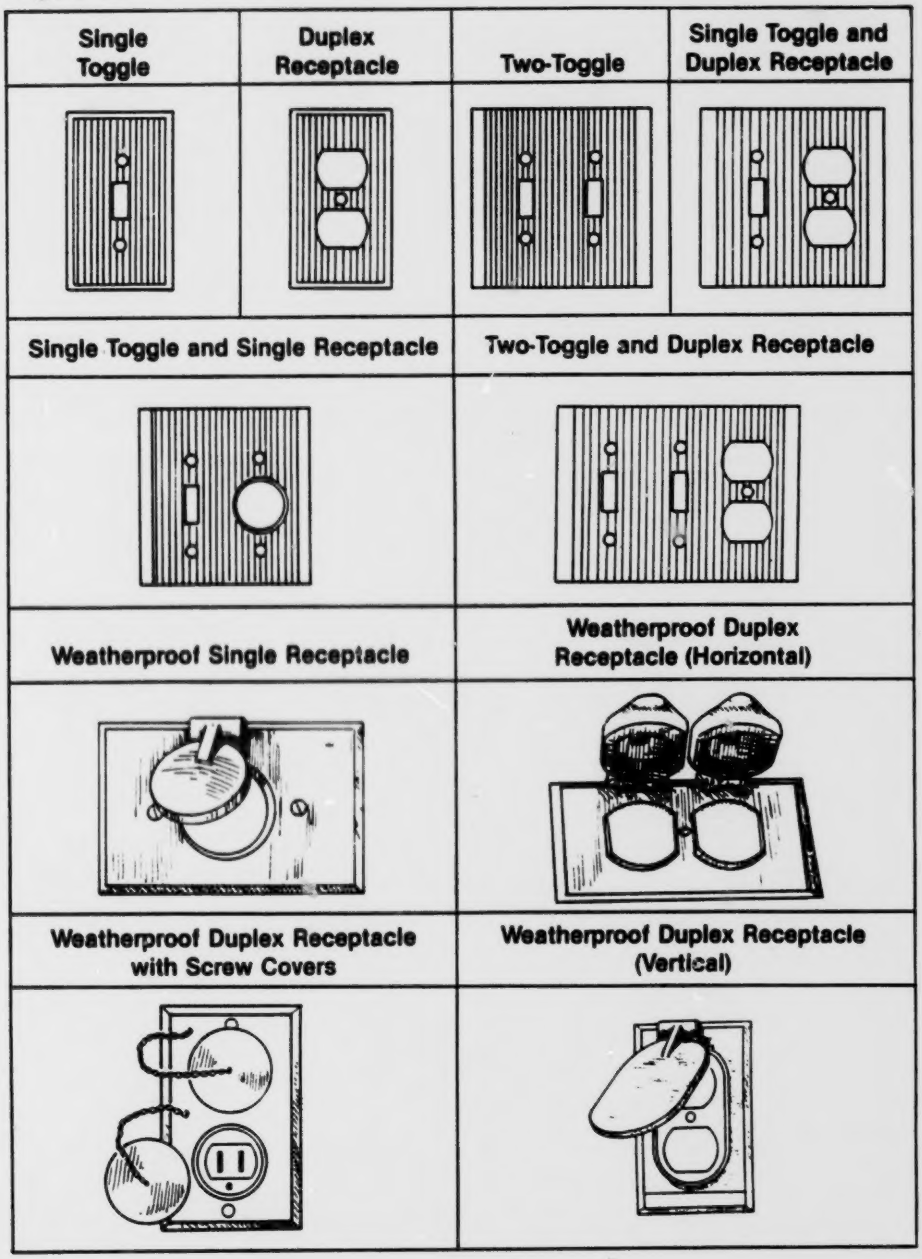
Blank	Single Receptacle
	
Duplex Receptacle	Single Toggle
	

Information Sheet

e. Wall plates

Note: These are usually available in plastic or metal, but also come in decorator types for interior walls.

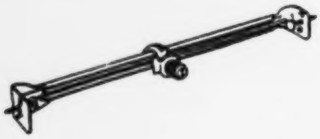
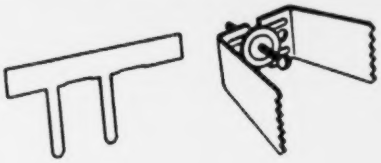
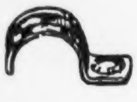
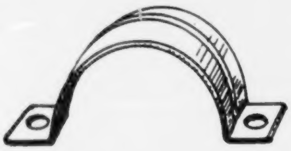
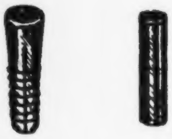
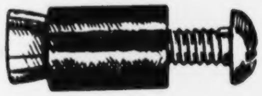
Figure 15

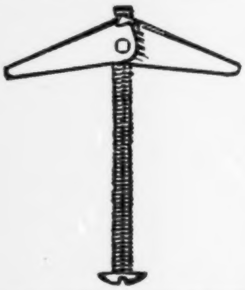
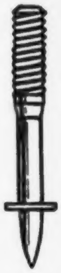
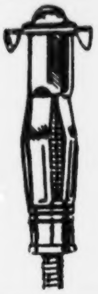

Single Toggle
Duplex Receptacle
Two-Toggle
Single Toggle and Duplex Receptacle
Single Toggle and Single Receptacle
Two-Toggle and Duplex Receptacle
Weatherproof Single Receptacle
Weatherproof Duplex Receptacle (Horizontal)
Weatherproof Duplex Receptacle with Screw Covers
Weatherproof Duplex Receptacle (Vertical)

Information Sheet

8. **Supports and anchors commonly used in electrical wiring** (Figure 16)

Figure 16

Bar hanger	**Switch-box supports**
	
One-hole strap	**Two-hole strap**
	
Plastic anchors	**Lead anchor**
	

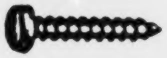
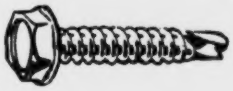
Toggle bolt	**Drive stud**	**Molly bolt**
		

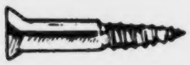
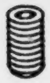
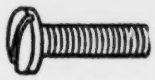
Information Sheet

9. **Screws, bolts, and nuts commonly used in electrical wiring** (Figures 17-19)

a. Screws

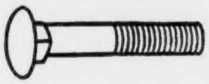
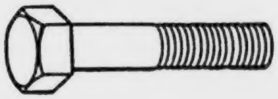
Figure 17

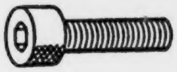
Sheet metal screw	Self-drilling screw
	

Wood screw	Set screw	Machine screw
		

b. Bolts

Figure 18

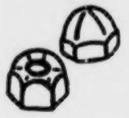
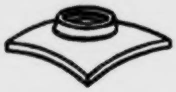
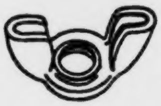
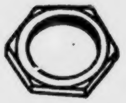
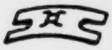
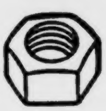
Carriage bolt	Hex-head bolt
	

Hex-socket-head bolt


Information Sheet

c. Nuts

Figure 19

Acorn nut	Spring nut
	
Wing nut	**Fixture nut**
	
Single-thread nut	**Plain hex nut**
	

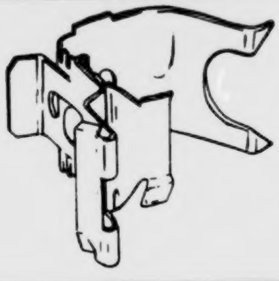
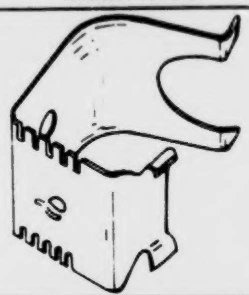
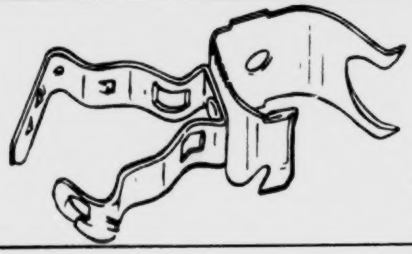
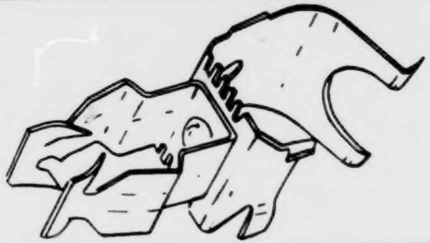
Information Sheet

10. **Classes of box-mounting devices for steel structures** (Figures 20-24)

    a. Metal stud clips for switch boxes

    Note: Some types of metal stud supports may require extra screws to secure them to studs.

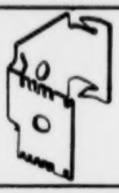
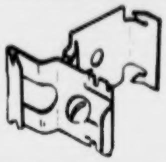
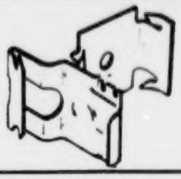
Figure 20

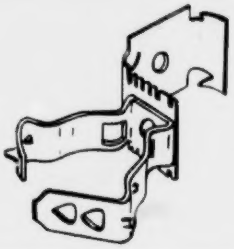
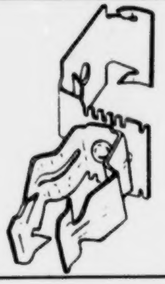
Riveted for Dry Wall, with Screw Adjustable ¼" to ¾"	**¼"-20 Thread Impression to Metal Stud**
	
½" to 1" Conduit to Metal Stud	**½" to 1" Conduit to Metal Stud**
	

Information Sheet

b. MF clips for switch boxes (metal stud fasteners)

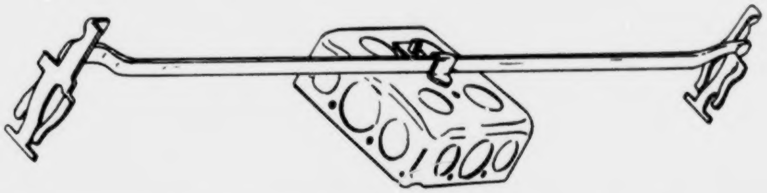
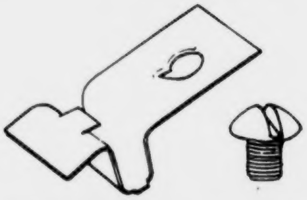
Figure 21

¼"-20 Thread Impression to Metal Stud	With Screw Adjustable ¼" through ¾"	Riveted for Flush Wall or ¼" to ¾" Dry Wall
		

Conduit on BX to Metal Stud	½" to 1" Conduit to Metal Stud
	

c. Acoustical tee-bar electrical box hanger and mounting clip

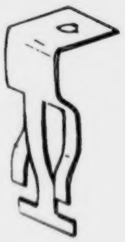
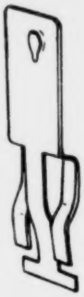
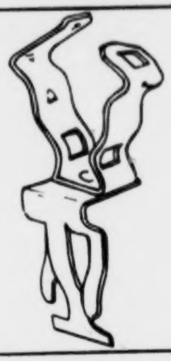
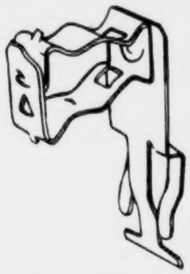
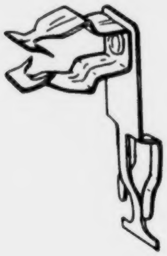
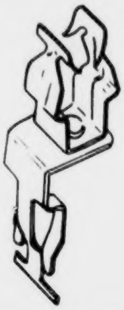
Figure 22

Acoustical "Tee-Bar" Electrical Box Hanger

Mounting Clip


Information Sheet

d. Acoustical tee-bar clips

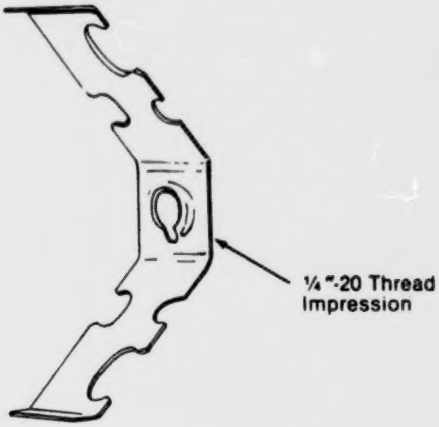
Figure 23

Top-Mount, with 1/4"-20 Thread Impression	**Side-Mount, with 1/4"-20 Thread Impression**	**Top-Mounted Conduit Clip for 3/8" or 1/2" to 3/4" Conduit**
		
With Side-Mounted Conduit Clip for 3/8" or 1/2" to 3/4" Conduit	**With Side-Mounted Conduit Clip for 1/2", 3/4" or 1" Conduit**	**With Top-Mounted Conduit Clip for 1/2" or 3/4" Conduit**
		

Information Sheet

e. Conduit box clip

Figure 24


¼"-20 Thread Impression

Basic Equipment
Unit 7

Assignment Sheet 1—Determine the Correct Number of Conductors for Boxfill

Name ______________________ Overall Rating __________

Evaluation criteria	**Rating**
Correct rule used	______
All figures measured	______
Nine of eleven answers correct per assignment sheet answers	______

Directions: Determine the correct number of conductors for boxfill for the problems below. To find boxfill, subtract two conductors per device and one conductor per one or more grounds from the maximum allowed number of conductors permitted according to the *National Electrical Code*, Article 370-6. Assume one ground wire for each problem.

Example: 4" × 2⅛" square box, two yoke- or strap-holding devices, #12 wire

1. Referring to box dimensions and wire size, locate the maximum number of conductors on chart in Table 370-16(a) (maximum number = 13).
2. Subtract two conductors for each yoke- or strap-holding device (13 – 2 = 11).
3. Subtract one conductor for ground (11 – 1 = 10).
4. Answer equals boxfill (boxfill = 10 conductors).

A. 4" × 2⅛", no yoke- or strap-holding device, round box, cable clamp, #12 wire

Boxfill = ______________________ conductors

B. 3¾" × 2" × 3½", one yoke- or strap-holding device, masonry box, #12 wire

Boxfill = ______________________ conductors

Assignment Sheet 1

C. 3″ × 2″ × 1½″, one yoke- or strap-holding device, #10 wire

Boxfill = ______________________________ conductors

D. 4″ × 2⅛″ × 1⅞″, one yoke- or strap-holding device, #10 wire

Boxfill = ______________________________ conductors

E. 4 11/16″ × 1½″, two yoke- or strap-holding devices, square box, #12 wire

Boxfill = ______________________________ conductors

F. 4″ × 1¼″, round box, #12 wire

Boxfill = ______________________________ conductors

G. 3″ × 2″ × 2½″, no yoke- or strap-holding device, #10 wire

Boxfill = ______________________________ conductors

Assignment Sheet 1

H. 3″ × 2″ × 3½″, no yoke- or strap-holding device, #10 wire

Boxfill = ______________________________ conductors

I. 4 × 2⅛″ × 1½″, no yoke- or strap-holding device, #12 wire

Boxfill = ______________________________ conductors

J. 4″ × 1¼″, two yoke- or strap-holding devices, square box, #12 wire

Boxfill = ______________________________ conductors

Basic Equipment
Unit 7

Job Sheet 1—Install Outlet Boxes on Wood Studs on a Framed Wall

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

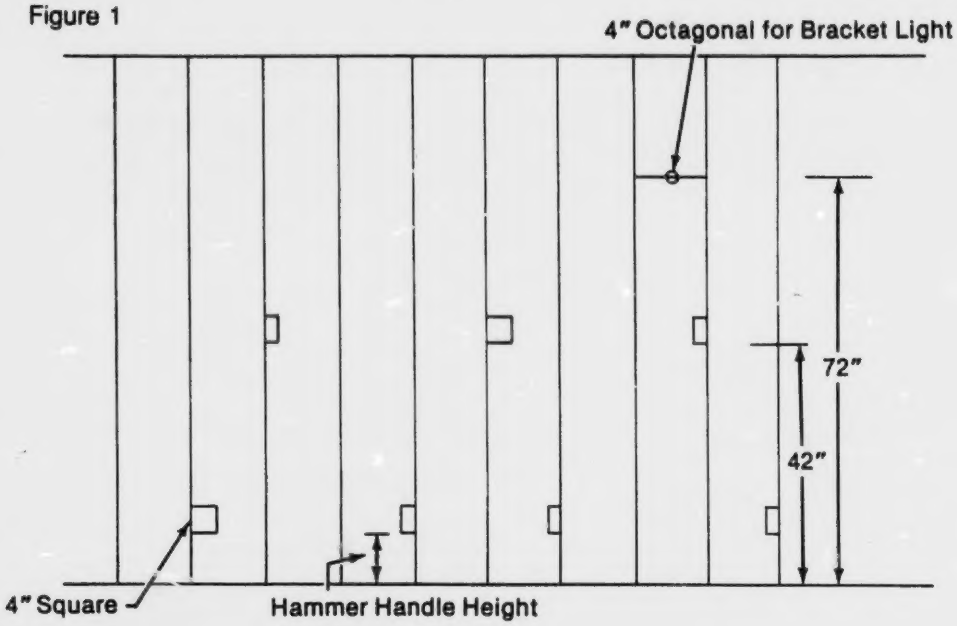
Evaluation criteria	Rating
Gathered and used appropriate equipment and materials	______
Performed procedure safely	______
Performed all steps in procedure	______
Performed steps in correct sequence	______
Cleaned work area	______

A. Equipment and materials

Pouch tools, including hammer and tape
8-foot section of framed wall with 2″ × 4″ studs
Five outlet boxes (plastic)
Two 4-inch square boxes
Two plaster rings
#8 mounting nails
4-inch octagon box
One expandable hanger bar
Construction blueprint showing locations and other necessary information for box installation (Figure 1)

Job Sheet 1

Figure 1



B. Procedure

☐ 1. View blueprint for installation information to determine location of boxes.

Note: Mount boxes to allow for ⅝-inch Sheetrock®.

☐ 2. Lay out job by marking studs where boxes are to be installed.

☐ 3. Place boxes on floor along wall where each is to be installed.

☐ 4. Measure heights, and mark studs for mounting boxes.

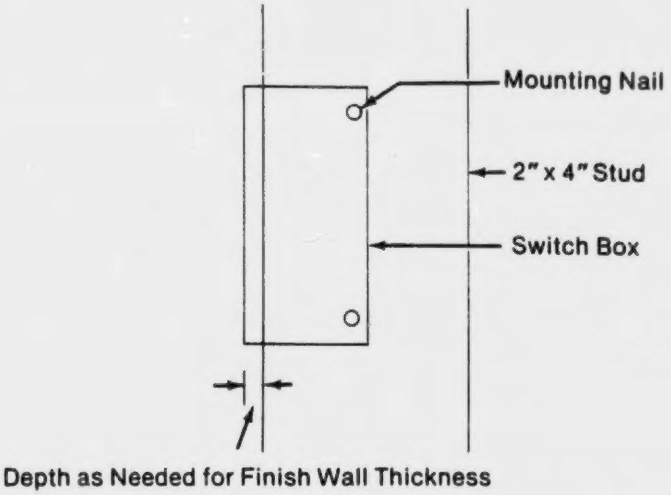
Note: A quick, accurate method for measuring for box installation is to cut a piece of conduit, lath, or other similar material to proper length from floor or floor plate to bottom of box. Boxes can be held on top of the measuring device and fastened to stud. This will prevent reading a rule for locating each box. A method often used in industry for height location of receptacle boxes is to set a hammer on the floor and position the box on top of the handle. The receptacle box can be fastened to the stud at that height.

Job Sheet 1

☐ 5. Mount electrical boxes to studs at the locations and heights marked, with front edge of boxes parallel to face of stud and extended ½ inch to allow for ⅝-inch Sheetrock®. (Figure 2)

Note: Four-inch square boxes are usually mounted with #8 or roofing nails, and switch boxes are usually mounted with #16 nails.

Figure 2: Switch Box Mounted on a 2" by 4" Wall Stud

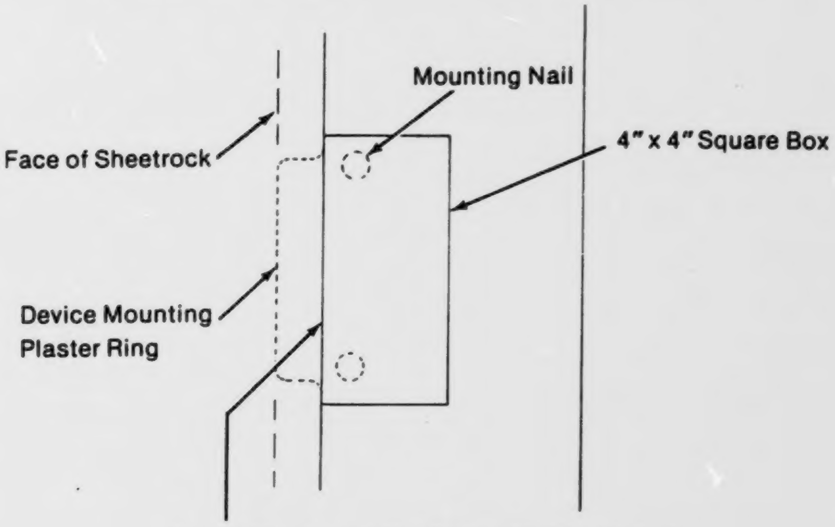

Mounting Nail
2" x 4" Stud
Switch Box
Depth as Needed for Finish Wall Thickness

Job Sheet 1

☐ 6. Mount 4-inch square boxes to studs at the height and location as marked with front edge of box flush with face of stud. (Figure 3)

Note: Set four-inch square boxes ½ inch lower than switch boxes, device screws inside.

Figure 3: 4″ × 4″ Box Mounted on 2″ × 4″ Stud


Mounting Nail
Face of Sheetrock
4″ x 4″ Square Box
Device Mounting Plaster Ring

Front of box should be flush with 2″ x 4″ stud.

7. Install octagonal outlet box for wall bracket light between two studs at location and height marked.

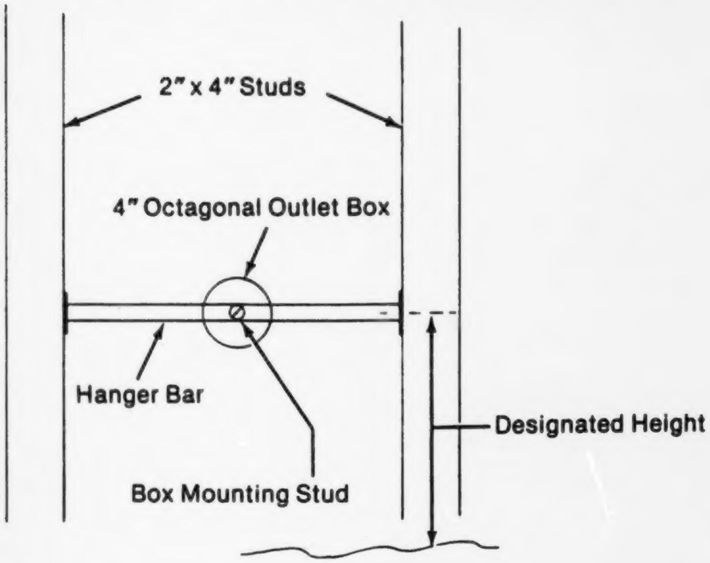
   ☐ a. Spread expandable hanger bar to proper length to properly fit between studs.

Job Sheet 1

☐ b. Attach hanger bar to studs. (Figure 4)

Note: Hanger bars are usually fastened to studs with #8 nails.

Figure 4: 4″ Octagonal Box Mounted on Hanger Bar


2″ x 4″ Studs
4″ Octagonal Outlet Box
Hanger Bar
Designated Height
Box Mounting Stud

☐ c. Attach octagonal box to hanger-bar stud.

Note: Have instructor evaluate project.

☐ 8. Clean work area, and carefully dismantle equipment and return it to proper storage.

Evaluator's comments: ______________________________

____

____

Basic Equipment
Unit 7

Job Sheet 2—Install Outlet Boxes on Steel Structures and Rods Using Caddy Clips

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Gathered and used appropriate equipment and materials	______
Performed procedure safely	______
Performed all steps in procedure	______
Performed steps in correct sequence	______
Cleaned work area	______

A. Equipment and materials

Stove bolt, ¼ inch by ½ inch
3-foot piece of ½-inch EMT
4-inch square outlet box, Raco #255 or equivalent
½-inch EMT connector
Two 3-foot pieces of ¼-inch rod
Two rod-hanger clamps. Caddy Catalog #708-2-4 or equivalent
Two conduit box clips, Caddy Catalog #4-1-2-4 or equivalent
Pouch tools

B. Procedure

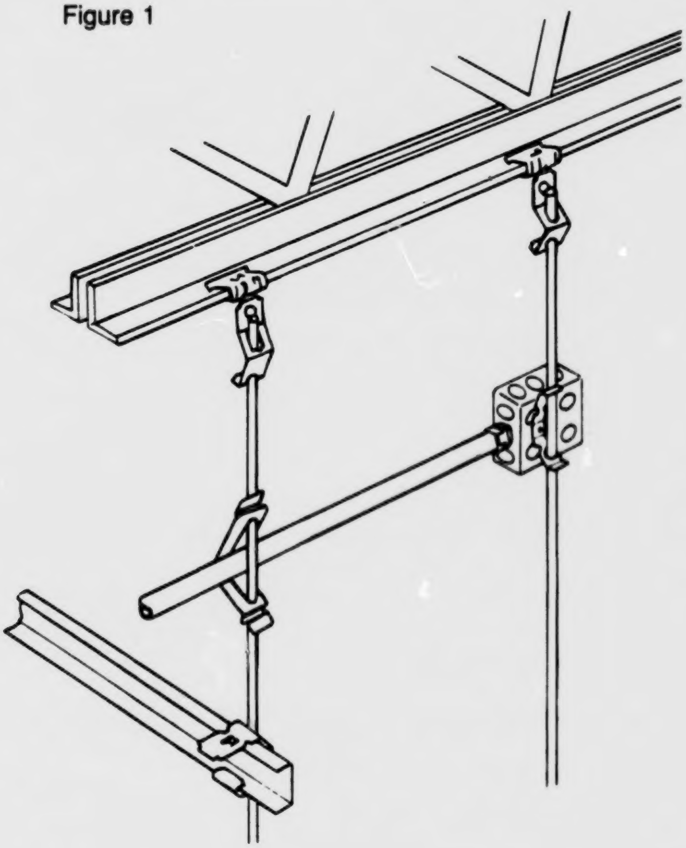
☐ 1. Install two ¼-inch rods in rod-hanger clamps.

☐ 2. Mount two rod-hanger clamps on suspended angle iron approximately 24 inches apart.

Job Sheet 2

☐ 3. Install ½-inch EMT in 4-inch square box. (Figure 1)

Figure 1

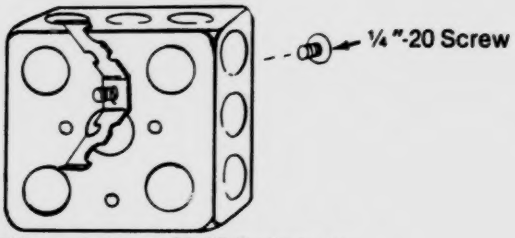


Used with permission of ERICO Products, Inc.

Job Sheet 2

☐ 4. Fasten rod-hanger clip to square box. (Figure 2)

Figure 2

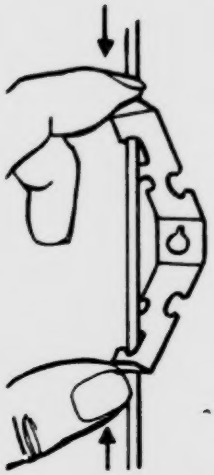


Used with permission of ERICO Products, Inc.

☐ 5. Mount box and EMT to the two ¼-inch rods. (Figure 2)

☐ 6. Adjust to proper height. (Figure 3)

Figure 3



Used with permission of ERICO Products, Inc.

Note: Have instructor evaluate your project.

☐ 7. Clean work area, and carefully dismantle your equipment and return it to proper storage.

Evaluator's comments: ____________________

____

____

Basic Equipment
Unit 7

Job Sheet 3—Install Outlet Boxes on Steel Studs Using Caddy Metal Clips for Switch Boxes

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	Rating
Gathered and used appropriate equipment and materials	______
Performed procedure safely	______
Performed all steps in procedure	______
Performed steps in correct sequence	______
Cleaned work area	______

A. Equipment and materials

Pouch tools
8-foot section of steel-stud wall
Three electrical boxes, Raco #560 or equivalent
4-inch square electrical box, Raco #211 or equivalent
Handy box, Raco #660 or equivalent
Metal stud clip, Caddy #MSB-625 or equivalent
Four MF clips for switch boxes, Caddy #MF-625 or equivalent

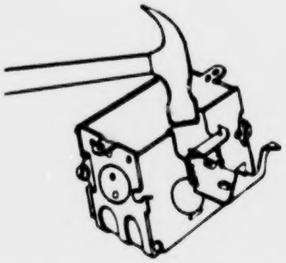
Job Sheet 3

B. Procedures

Note: Boxes may be mounted at nonregulation places since intent of this job sheet is to acquaint students with box mounting methods when working with steel-stud walls.

☐ 1. Mount metal stud clip to switch box. (Figure 1)

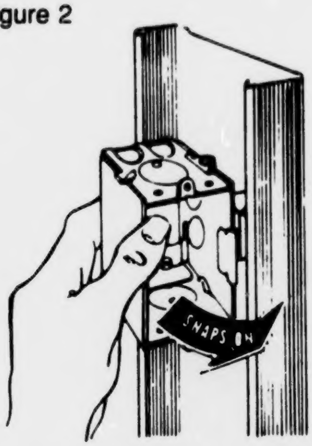
Figure 1



Used with permission of ERICO Products, Inc.

☐ 2. Mount box and clip to steel stud. (Figures 2 and 3)

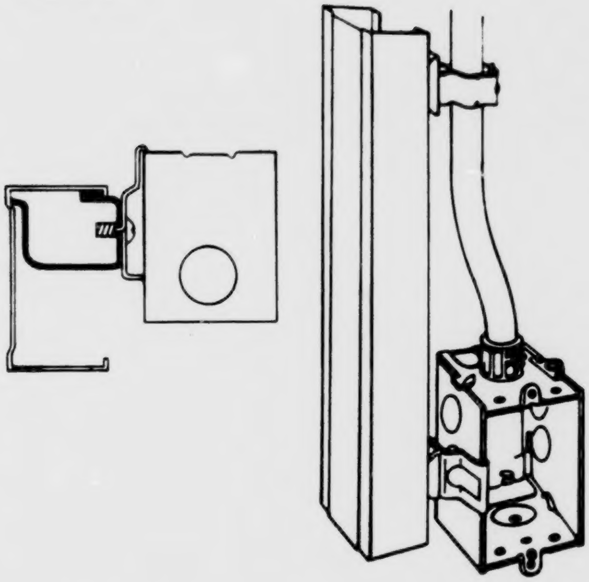
Figure 2



Used with permission of ERICO Products, Inc.

Job Sheet 3

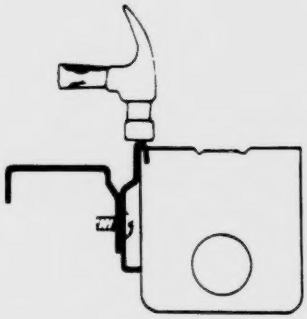
Figure 3



Used with permission of ERICO Products, Inc.

☐ 3. Mount one MF clip on each of the other boxes. (Figure 4)

Figure 4

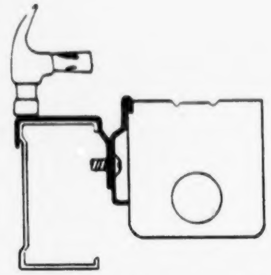


Used with permission of ERICO Products, Inc.

Job Sheet 3

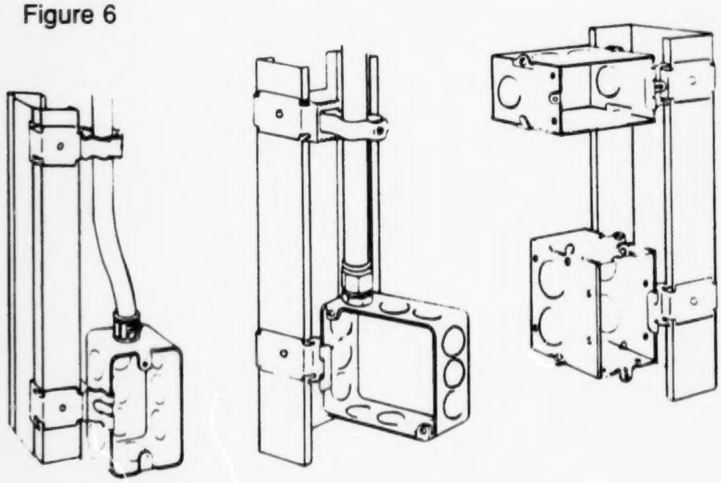
☐ 4. Mount clips and boxes to metal studs. (Figures 5 and 6)

Figure 5



Used with permission of ERICO Products, Inc.

Figure 6



Used with permission of ERICO Products, Inc.

Note: Have instructor evaluate your work.

☐ 5. Clean work area, and carefully dismantle your equipment and return it to proper storage.

Evaluator's comments: ____________________

____

____

Basic Equipment
Unit 7

Job Sheet 4—Install Masonry Boxes in a Block Wall Using Caddy Metal Clips for Switch Boxes

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

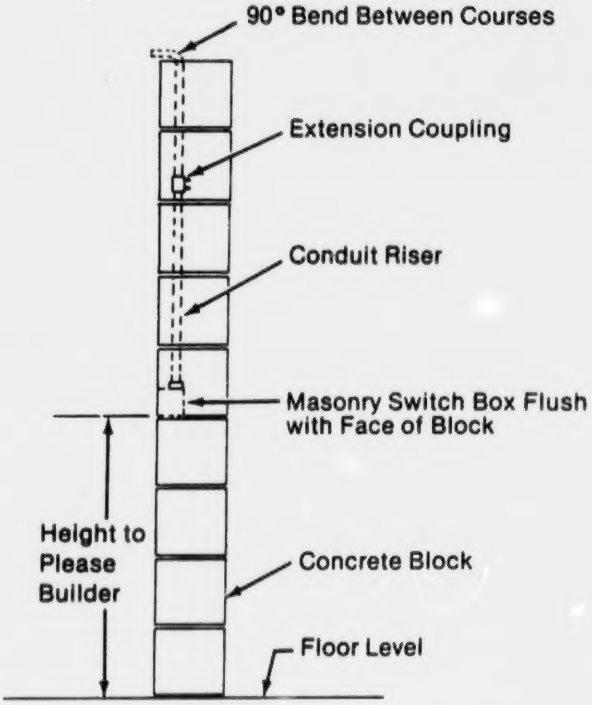
Evaluation criteria	**Rating**
Gathered and used appropriate equipment and materials	______
Performed procedure safely	______
Performed all steps in procedure	______
Performed steps in correct sequence	______
Cleaned work area	______

A. Equipment and materials

Pouch tools
Hacksaw
Two masonry switch boxes, Raco #695 or equivalent
Two masonry two-gang boxes, Raco #696 or equivalent
20 feet of ½-inch EMT
Four ½-inch EMT setscrew connectors
Four ½-inch EMT setscrew couplings
Conduit bender
Plan (Figure 1)

Job Sheet 4

Figure 1


90° Bend Between Courses
Extension Coupling
Conduit Riser
Masonry Switch Box Flush with Face of Block
Height to Please Builder
Concrete Block
Floor Level

B. Procedure

Note: This job must be done in cooperation with the masonry instructor because the electrical components are to be installed as the block wall is constructed.

☐ 1. Open ½-inch knockout hole nearest to the back of box so that EMT will be in the hollow of the cement blocks.

Note: Masonry boxes generally have concentric ½-inch and ¾-inch knockout punchings; exercise care to break out on the ½-inch part.

☐ 2. Cut eight pieces of ½-inch EMT, approximately 30 inches long.

Note: Cut all eight pieces exactly the same length.

Job Sheet 4

☐ 3. Install ½-inch EMT connectors in each of the four masonry box knockout holes.

Note: If during knockout removal, the ¾-inch punching breaks out instead of the ½-inch punching, see your instructor. You will need two ¾-inch by ½-inch reducing washers for each ¾-inch hole to properly install ½-inch EMT.

☐ 4. Install a 40-inch piece of EMT in each connector.

Note: The person laying the blocks must install each block down over the vertical conduit.

☐ 5. Deliver the made-up boxes to the block layer.

Note: The electrician and the block layer must work together to be sure that the boxes are installed in the proper locations, and correctly installed with the EMT extending upward in the wall. See Figure 1.

☐ 6. When the block wall reaches desired height, install the masonry boxes, extending conduit upward.

☐ 7. Supervise the installation of the next layers of blocks until only a short portion of the conduit is visible above the wall.

Note: The block mason must raise the blocks above the height of the conduit, and then lower the next blocks over the conduit so that it extends upward through the hollow of the blocks.

☐ 8. Install 30-inch pieces of conduit equipped with couplings to increase the height for next layers of blocks.

Note: The conduit is extended upward 2 or 3 feet at a time as the height of the wall increases.

☐ 9. Make a 90-degree bend in the conduit when the wall and conduit reach required height.

Note: A 90-degree bend will allow the conduit to stick out of the wall between courses. This will prevent having to cut into the blocks.

Note: Have the instructor evaluate your work.

☐ 10. Clean work area, and carefully dismantle equipment and return it to proper storage.

Evaluator's comments: ____________________

____

____

Basic Theory
Unit 8

Objective Sheet

Unit Objective

After completing this unit, the student should be able to identify electrical schematic symbols and apply Ohm's law formulas. The student should demonstrate these competencies by completing the assignment sheets and scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to basic electrical theory with their correct definitions.
2. Select true statements concerning the principles of electron flow.
3. Select words to complete statements concerning basic sources of electrical generation.
4. Complete statements concerning the distribution of electricity.
5. Match electrical schematic symbols with their names.
6. Distinguish between diagrams and schematics.
7. Select units of measure to complete definitions of electrical abbreviations.
8. State Ohm's law.
9. Draw Ohm's law in wheel expression.
10. List uses of Ohm's law.
11. State the unit of measure formulas from Ohm's law.
12. State Ohm's law for power.
13. Draw Ohm's law for power in wheel expression.
14. List uses of Ohm's law for power.
15. State the unit of measure formulas from Ohm's law for power.

Objective Sheet

16. Draw a diagram of the power distribution supplying your school shop. (Assignment Sheet 1)
17. Solve problems for unknown voltage. (Assignment Sheet 2)
18. Solve problems for unknown amperage. (Assignment Sheet 3)
19. Solve problems for unknown resistances and wattages. (Assignment Sheet 4)
20. Solve problems for an unknown quantity. (Assignment Sheet 5)

Basic Theory
Unit 8

Suggested Activities

Instructional Plan

Preparation

1. Read the unit carefully and plan for instruction. Study the specific objectives to determine the order in which you will present them.

2. Review Teaching Suggestions section that follows. Plan for classroom activities.

3. Plan your presentation to take advantage of student learning styles and to accommodate special needs students.

4. Make transparencies from the transparency masters included with this unit. The masters appear in the teacher edition only and are intended to be used with the following objectives:

   TM 1—Friction Produces Electricity (Objective 3)
   TM 2—Pressure Produces Electricity (Piezoelectric Effect) (Objective 3)
   TM 3—Heat Produces Electricity (Thermocouple) (Objective 3)
   TM 4—Light Produces Electricity (Objective 3)
   TM 5—Chemical Action Produces Electricity (Objective 3)
   TM 6—Magnetism Produces Electricity (Objective 3)
   TM 7—Ohm's Law in Wheel Expression (Objective 9)
   TM 8—Three Formulas from Ohm's Law (Objective 11)
   TM 9—Ohm's Law for Power in Wheel Expression (Objective 13)
   TM 10—Three Formulas from Ohm's Law for Power (Objective 15)

5. Obtain films, videotapes, and other resources to supplement instruction of this unit. See ordering information in the Suggested Supplemental Resources section that follows.

6. Develop teaching plan. Adjust for different learning styles.

7. Make copies of Unit Evaluation Form.

Delivery and Application

8. Provide students with unit of instruction.

9. Discuss unit and specific objectives.

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Suggested Activities

10. Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.

11. Discuss the assignment sheets and schedule due dates. Review criteria for evaluation of these activities.

Evaluation

12. Discuss the use of the Unit Evaluation Form with students. Discuss the rating scale that will be used for student evaluation.

13. Make copies of the written test. Add or modify test items as needed.

14. Give written test.

15. Compile assignment sheet ratings and written test scores on the Unit Evaluation Form. Include any additional assignments.

16. Reteach and retest as required.

Teaching Suggestions

Note: Skill areas appearing in boldface type in the Teaching Suggestions refer to the academic and workplace skills identified by the American Society for Training and Development (ASTD) and the U.S. Department of Labor. These have been adapted by MAVCC.

1. Provide students with enough practice concerning basic theory to meet local employment needs. Skill areas: **Applying scientific principles, math**

2. Have representatives from a local power company discuss the distribution of electricity in your community. Coordinate this activity with the completion of Assignment Sheet 1. Skill areas: **Applying scientific principles, listening, writing, math**

3. Have students construct a model or draw diagrams of an atom, showing its makeup. Skill areas: **Creative thinking, writing**

4. Show or give examples of basic sources of generation.

5. Relate Ohm's law to series and parallel circuits.

Suggested Activities

Resources Used in Developing This Unit

1. *Basic Electricity Review.* Rockville, MD: NUS Training Corporation, A Halliburton Company.
2. Miller, Rex. *Industrial Electricity.* Peoria, IL: Bennett Publishing Company.
3. Taylor, Mark. *Residential Wiring.* Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1983.
4. Turner, J. Howard. *Understanding Electricity and Electrical Terms.* Athens, GA: American Association for Vocational Instructional Materials.

Suggested Supplemental Resources

1. Film — *Basic Electricity Review.* NUS Training Corporation, 1350 Piccard Drive, Rockville, MD 20850.
2. Videotapes
    a. *Electron Flow*, VHS, 15 minutes. Bergwall Productions, Inc., 540 Baltimore Pike, Chadds Ford, PA 19317. Phone (800) 645-3565.
    b. *What is Electricity*, VHS, 9 minutes.
    c. *Current Flow*, VHS, 9 minutes.
    d. *Electrical Power*, VHS 11 minutes.

    Note: Order Videos b-d from International Film Bureau Incorporated, 332 S. Michigan Avenue, Chicago, IL 60604-4382. Phone (800) 432-2241.

Instructions for Evaluating Student Performance

Assignment Sheets—Be sure the student understands the criteria on which the evaluation is based. Assign a point value to each criterion and convert the total points to a percentage for grading.

> Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily achieved the step(s) for each checkpoint area. If the student is unable to correctly complete the procedure, have the student review the materials and try again.

Suggested Activities

Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria which have been provided as part of the job sheet. Complete the rating by assigning a point value to each criterion and by converting the point total to a percentage for grading. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) which best fits your program needs.

Option A

4 - Skilled—Can perform job with no additional training.
3 - Moderately skilled—Has performed job during training program; limited additional training may be required.
2 - Limited skill—Has performed job during training program; additional training is required to develop skill.
1 - Unskilled—Is familiar with process, but is unable to perform job.

Option B

Yes—Can perform job with no additional training.

No—Is unable to perform job satisfactorily.

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Basic Theory
Unit 8

Answers to Assignment Sheets

Assignment Sheet 1 — Evaluated using the assignment sheet criteria

Assignment Sheet 2

A.	120	F.	110
B.	240	G.	440
C.	24	H.	120
D.	12	I.	115
E.	230	J.	125

Assignment Sheet 3

A.	19.2	F.	50
B.	10	G.	11
C.	22	H.	20
D.	3	I.	6
E.	8	J.	12

Assignment Sheet 4

A.	60	F.	2,640
B.	2.5	G.	690
C.	2.4	H.	8,800
D.	46	I.	11,500
E.	3	J.	12

Assignment Sheet 5

1. E = IR
   2.5 x 9.6 = 24 volts

2. R = E/I
   460/100 = 4.6 ohms

3. P = IE
   3.5 x 12 = 42 watts

4. E = IR
   0.500 x 500 = 250 volts

5. I = P/E
   100/120 = 0.833 amps

6. P = EI
   208 x 600 = 124,800 watts
   R = E/I
   208/600 = 0.347 ohms

7. I = P/E
   20/50 = 0.4 amps
   R = E/I
   50/0.4 = 125 ohms

Answers to Assignment Sheets

8. I = E/R
   10/2200 = 0.0045 amps
   P = IE
   0.0045 x 10 = 0.045 watts

9. I = P/E
   100/100 = 1 amp
   R = E/I
   100/1 = 100 ohms

10. R = E/I
    480/1000 = 0.48 ohms
    P = IE
    1000 x 480 = 480,000 watts

Basic Theory
Unit 8

Answers to Written Test

1. a. 2
   b. 6
   c. 1
   d. 3
   e. 4
   f. 5

2. a, b, e

3. a. Friction
   b. Crystalline
   c. Dissimilar
   d. Photosensitive
   e. Chemical action
   f. A piece of wire

4. a. Generating plant
   b. Stepped up
   c. Transmission lines
   d. Transformers

5. a. 7
   b. 9
   c. 12
   d. 15
   e. 4
   f. 2
   g. 5
   h. 8
   i. 10
   j. 14
   k. 16
   l. 18
   m. 1
   n. 17
   o. 13
   p. 11
   q. 3
   r. 6

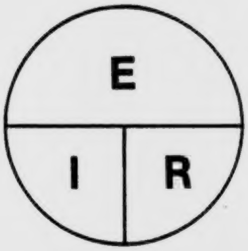
6. a

7. a. Volts
   b. Amps
   c. Ohms
   d. Watts

8. **Ohm's law** — The current in an electric circuit equals the pressure (volts) divided by the resistance.

Answers to Written Test

9.

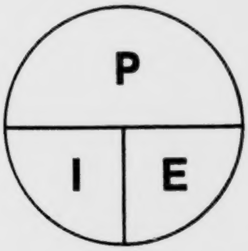


10. a. Calculating circuit resistance
    b. Calculating circuit amperage
    c. Calculating circuit voltage

11. a. Volts = Amps × Ohms or $E = I \times R$
    b. Amps = Volts + Ohms or $I = E/R$
    c. Ohms = Volts + Amps or $R = E/I$

12. **Ohm's law for power** — The power in an electrical circuit equals the current (amperes) multiplied by the electromotive force (volts).

13.



14. a. Calculating circuit wattage
    b. Calculating circuit voltage
    c. Calculating circuit amperage

15. a. Watts = Amps × Volts or $P = I \times E$
    b. Amps = Watts + Volts or $I = P/E$
    c. Volts = Watts + Amps or $E = P/I$

Basic Theory
Unit 8

Written Test

Name ______________________________ Score ____________

1. Match terms related to basic electrical theory with their correct definitions. Write the correct numbers in the blanks.

______a. Invisible energy

______b. Unit of measure of the power of an electric circuit

______c. Unit of measure of the intensity of the electron flow in a circuit

______d. Electrons transferring from one atom to another

______e. Unit of measure of the opposition to electron flow in a circuit

______f. Unit of measure of electromotive force or potential difference

1. Amp (ampere)
2. Electricity
3. Electron flow
4. Ohm
5. Volt
6. Watt

2. Select true statements concerning the principles of electron flow. Write an "X" in the blank before each true statement.

______a. Electricity is the flow of one electron to another.

______b. Atoms contain both protons and electrons.

______c. Protons always have a negative charge.

______d. Electrons always have a positive charge.

______e. Generation occurs when an outside force of power excites the electron flow and electricity is produced.

Written Test

3. Select words to complete the following list of statements concerning basic sources of electrical generation. Circle the word(s) that best completes each statement.

    a. (Chemical action, Friction) produces electricity when two materials are rubbed together.

    b. Pressure produces electricity when pressure is applied to (crystalline, magnetic) substances.

    c. Heat produces electricity when it is applied to the junction of two (similar, dissimilar) metals.

    d. Light produces electricity when it strikes a (reflective, photosensitive) material.

    e. (Chemical action, Friction) produces electricity when that action takes place between two metals in a cell.

    f. Magnetism produces electricity when a magnet is moved past (another magnet, a piece of wire).

4. Complete the following list of statements concerning distribution of electricity. Write in the blanks the word(s) that best completes each statement.

    a. Power is produced at the ________________ ________________.

    b. Voltage is ________________ ________________ for high-voltage transmission.

    c. Voltage is moved from one area to another through high-voltage ________________ ________________.

    d. Voltage is stepped down and moved through ________________ for public use.

Written Test

5. Match electrical schematic symbols with their names. Write the correct numbers in the blanks.

______a. Normally closed contact

______b. Thermal resistor

______c. Ground connection

______d. Single-pole, single-throw switch

______e. Alternating current motor

______f. Temperature actuated switch (opens on rise)

______g. Transformer

______h. Fuse

______i. Fixed resistor or load

______j. Wire connection

______k. Three-way switch

______l. Circuit breaker

______m. Double-pole, single-throw switch

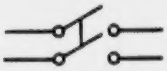
______n. Incandescent lamp

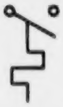
______o. Wire crossover

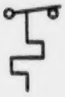
______p. Variable resistor or load

______q. Temperature-actuated switch (closes on rise)

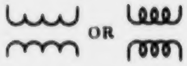
______r. Normally open contact

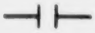
1. 

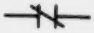
2. 

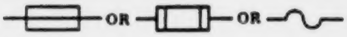
3. 

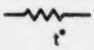
4.

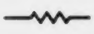
5. 

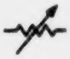
6. 

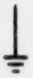
7. 

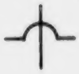
8. 

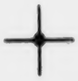
9. 

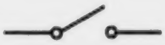
10. 

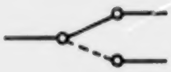
11. 

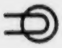
12. 

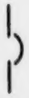
13. 

14. 

15. 

16. 

17. 

18. 

Written Test

6. Distinguish between diagrams and schematics. Write a "D" in the blank before the description of diagram.

   ______a. Drawing-type illustrations of actual equipment and devices

   ______b. Line-type illustrations that use symbols for equipment and devices

7. Select units of measure to complete definitions of electrical abbreviations. Circle the correct unit of measure.

   a. E — Electromotive force in (watts, volts)

   b. I — Intensity in (amps, ohms)

   c. R — Resistance in (volts, ohms)

   d. P — Power in (watts, amps)

8. State Ohm's law.

   ____

   ____

   ____

9. Draw Ohm's law in wheel expression.

10. List three uses of Ohm's law.

    a. ____

    b. ____

    c. ____

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Written Test

11. State the unit of measure formulas from Ohm's law.

    a. Volts = ______________________________

    b. Amps = ______________________________

    c. Ohms = ______________________________

12. State Ohm's law for power.

    ____

    ____

    ____

13. Draw Ohm's law for power in wheel expression.

14. List three uses of Ohm's law for power.

    a. ______________________________

    b. ______________________________

    c. ______________________________

15. State the unit of measure formulas from Ohm's law for power.

    a. Watts = ______________________________

    b. Amps = ______________________________

    c. Volts = ______________________________

***Permission to duplicate this test is granted.**

Basic Theory
Unit 8

Unit Evaluation Form

Student Name ____________________ Unit Rating ________

Assignment Sheet 1—Draw a Diagram of the Power Distribution Supplying Your School Shop Rating ______

Comments: ______________________________

____

Assignment Sheet 2—Solve Problems for Unknown Voltage Rating ______

Comments: ______________________________

____

Assignment Sheet 3—Solve Problems for Amperage Rating ______

Comments: ______________________________

____

Assignment Sheet 4—Solve Problems for Unknown Resistances and Wattages Rating ______

Comments: ______________________________

____

Assignment Sheet 5—Solve Problems for an Unknown Quantity Rating ______

Comments: ______________________________

____

Written Test Scores

Pretest ______ Posttest ______ Other ______

Other ______________________________

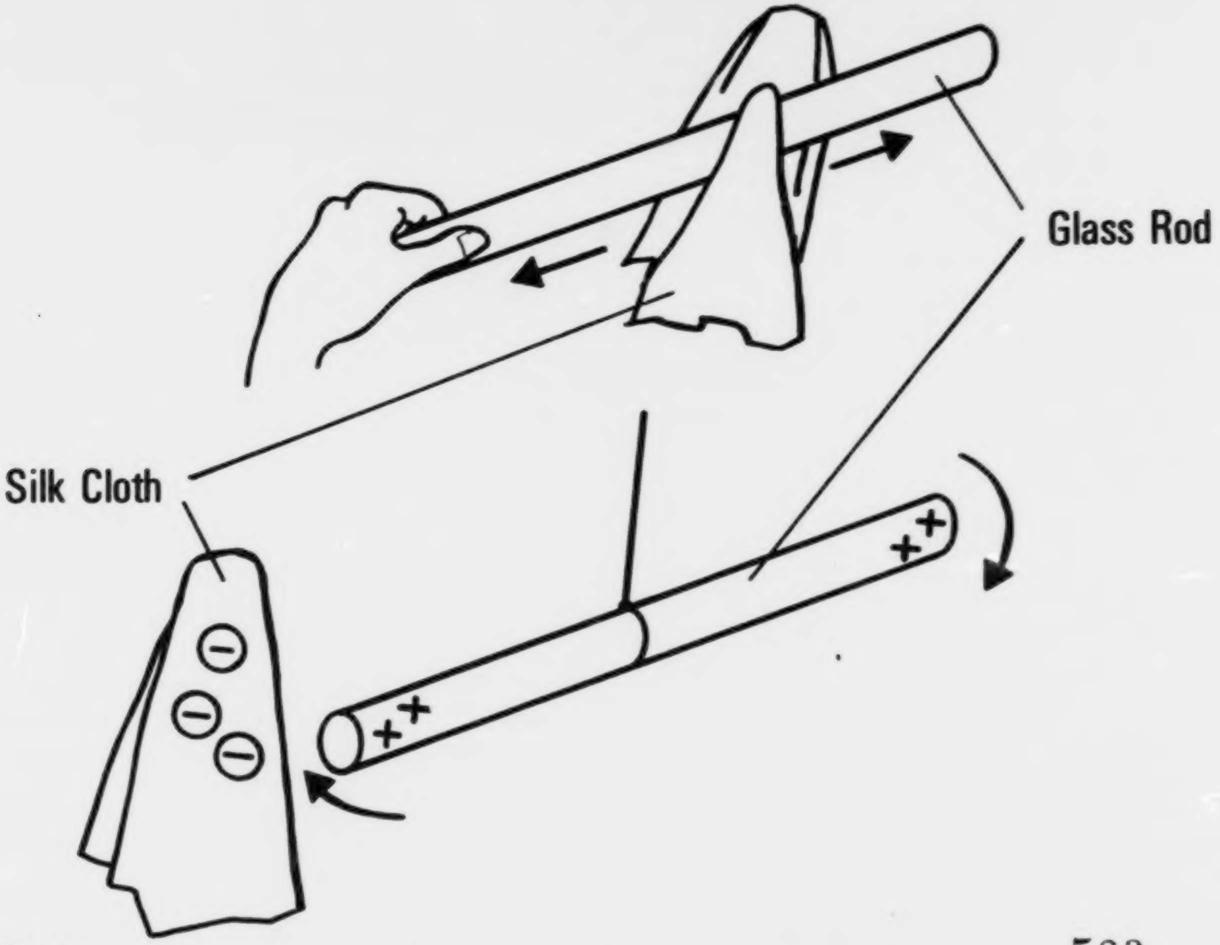
____

Teacher Signature ____________________ Date ________

Student Signature ____________________ Date ________

***Permission to duplicate this form is granted.**

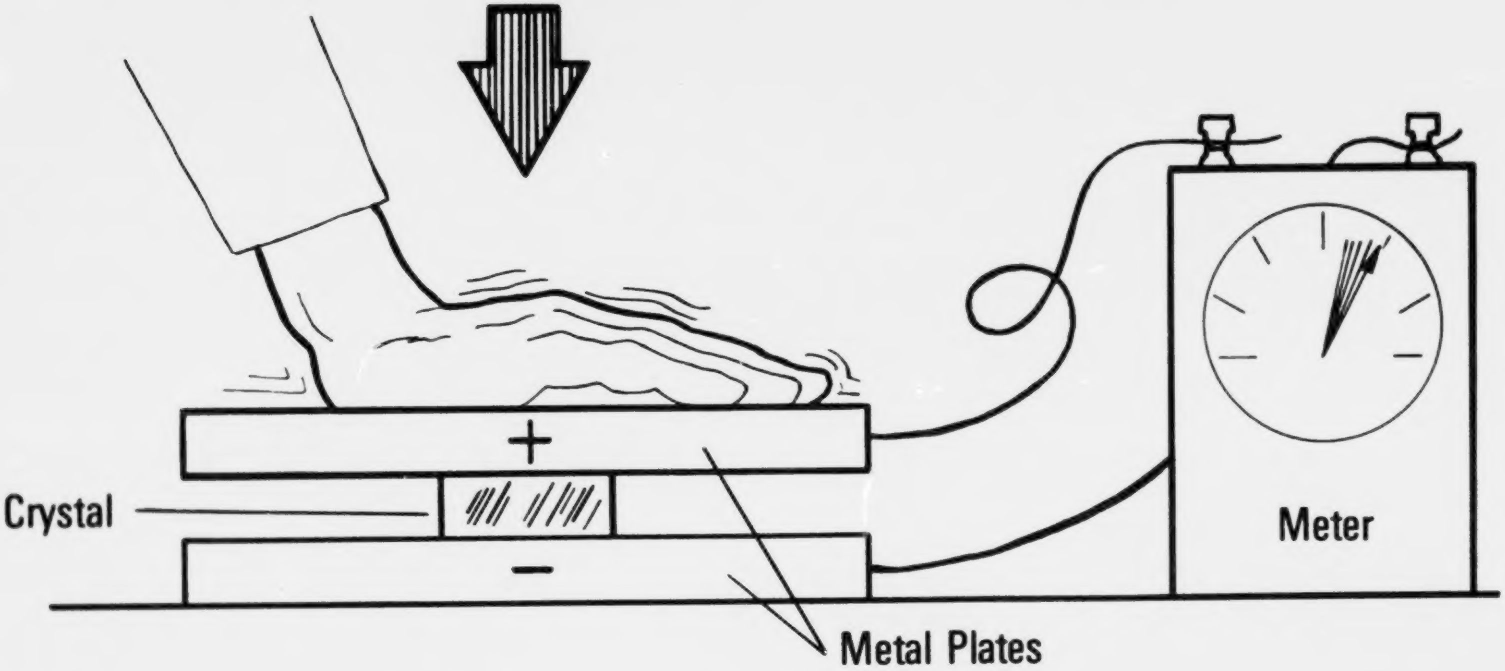
Friction Produces Electricity


Glass Rod
Silk Cloth
+ +
+ +
−
−
−

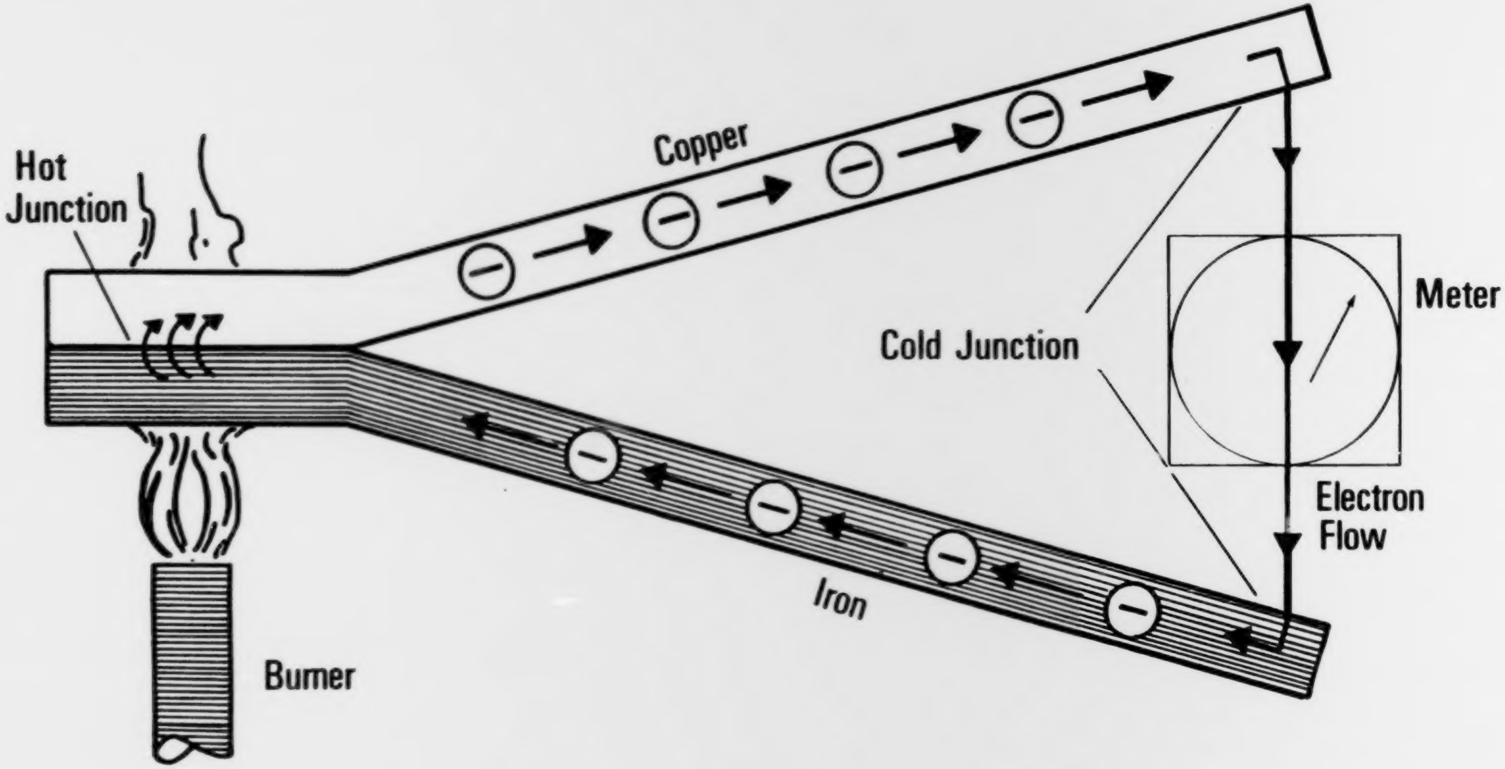
Basic Wiring, Unit 8
Teacher Page 17

TM 1

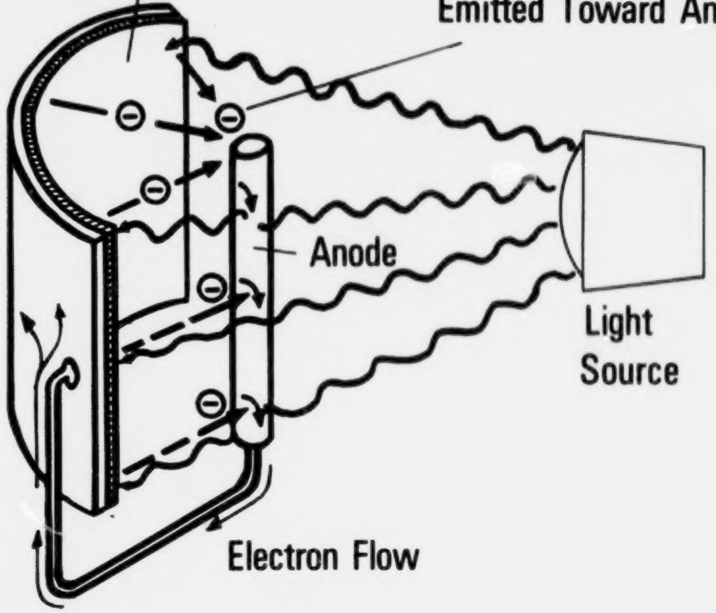
Pressure Produces Electricity
(Piezoelectric Effect)


+
Crystal
−
Meter
Metal Plates

Heat Produces Electricity
(Thermocouple)


Hot Junction
Copper
Meter
Cold Junction
Electron Flow
Iron
Burner

Light Produces Electricity



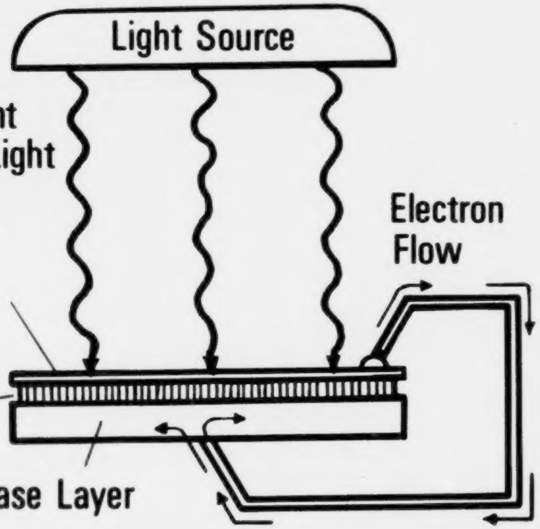
Photosensitive Silver Oxide Surface

Electrons Emitted Toward Anode

Anode

Light Source

Electron Flow



Light Source

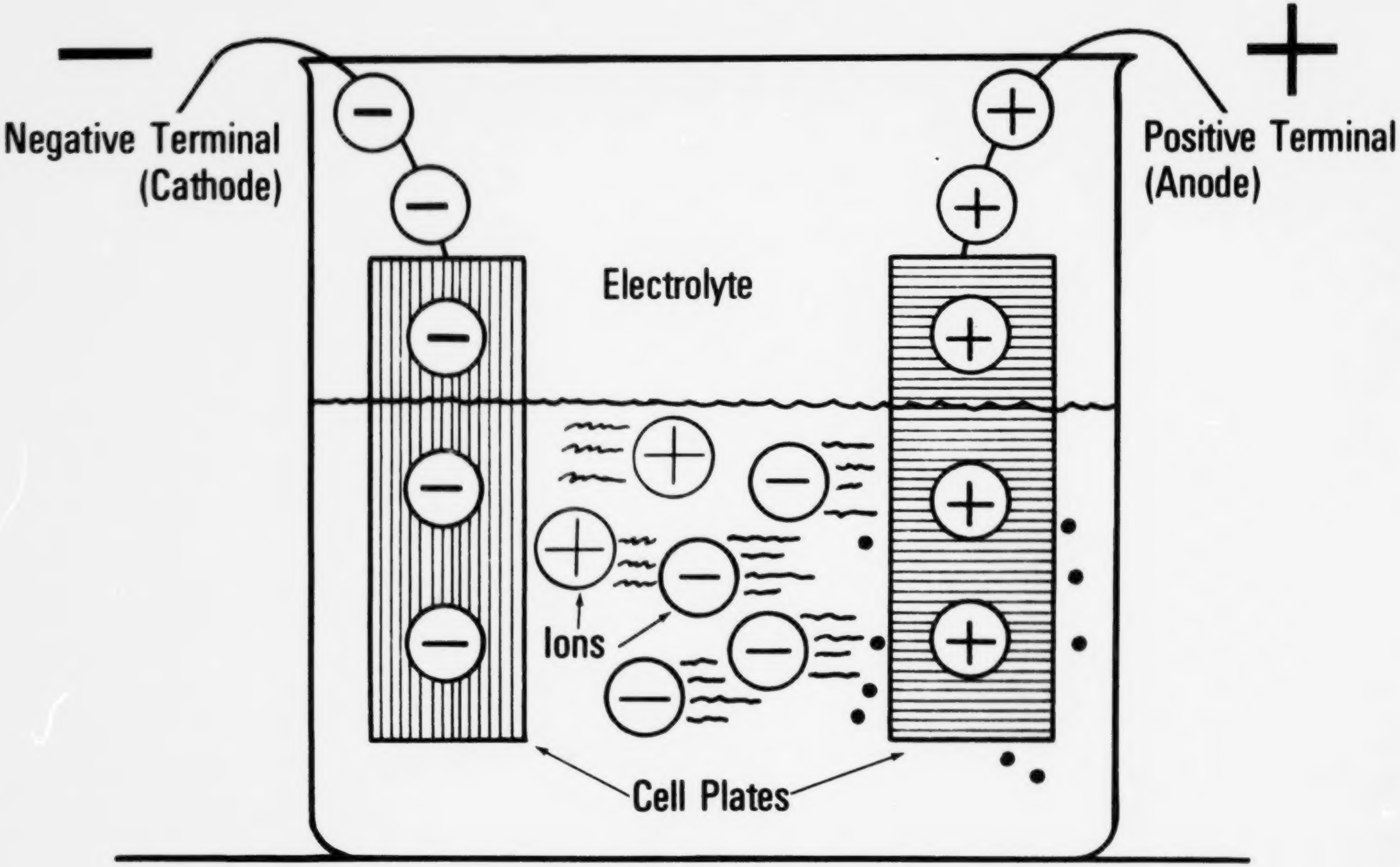
Semitransparent Layer Passes Light and Collects Photoelectrons

Electron Flow

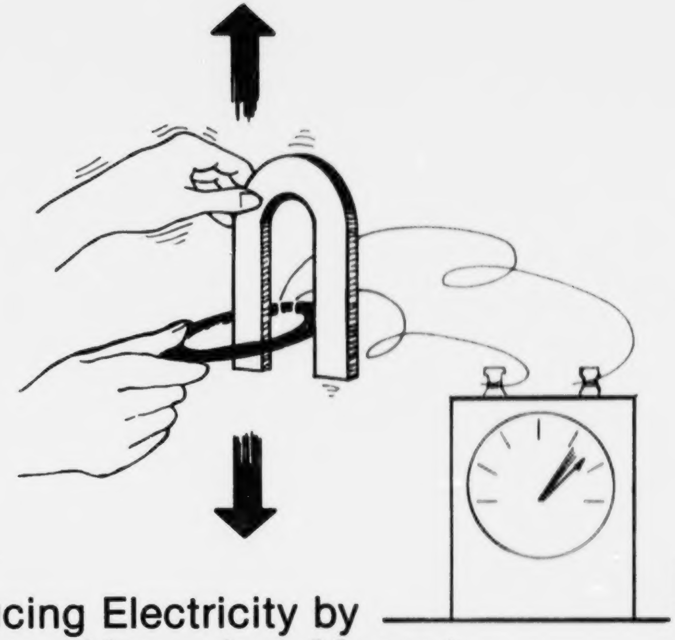
Photosensitive Copper Oxide

Pure Copper Base Layer

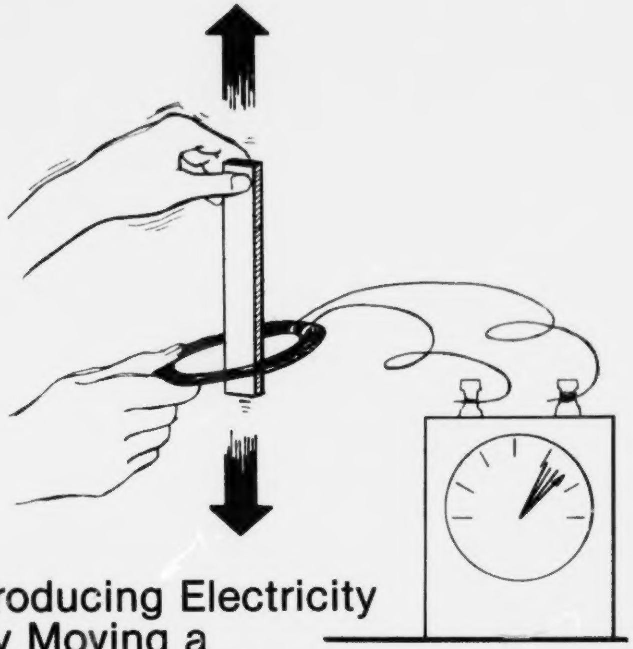
Chemical Action Produces Electricity


—
Negative Terminal
(Cathode)
+
Positive Terminal
(Anode)
Electrolyte
Ions
Cell Plates

Magnetism Produces Electricity



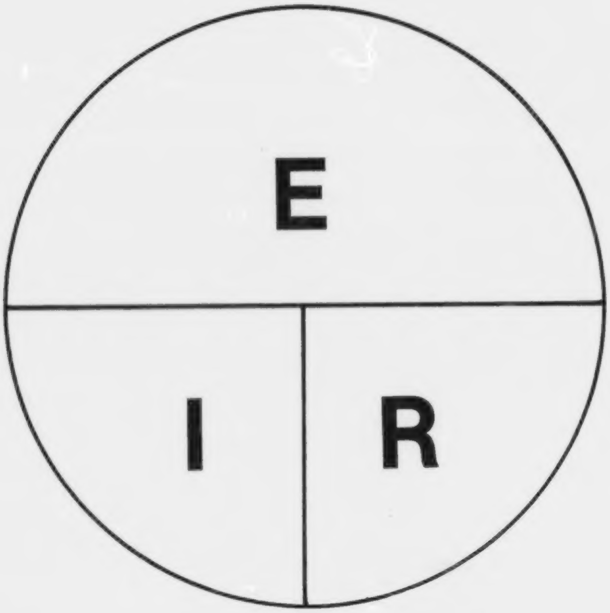
Producing Electricity by Moving a Horseshoe Magnet Through a Coil of Wire



Producing Electricity by Moving a Bar Magnet Through a Coil of Wire

This principle is used in generators.

Ohm's Law in Wheel Expression



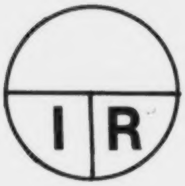
E = volts

I = amps

R = ohms

Three Formulas from Ohm's Law

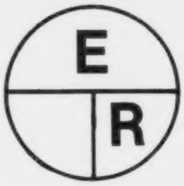
$E =$



or $E = I \times R$

or Volts = Amps × Ohms

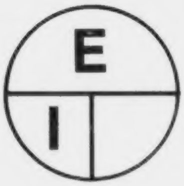
$I =$



or $I = E/R$

or Amps = Volts ÷ Ohms

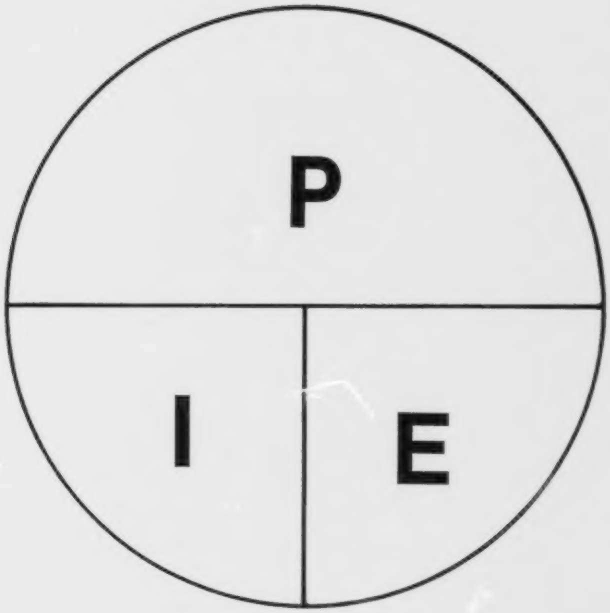
$R =$



or $R = E/I$

or Ohms = Volts ÷ Amp

Ohm's Law for Power in Wheel Expression



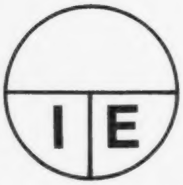
P = Watts

I = Amps

E = Volts

Three Formulas from Ohm's Law for Power

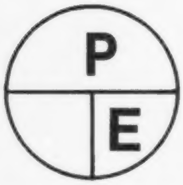
P =



or $P = I \times E$

or Watts = Amps × Volts

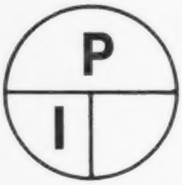
I =



or $I = P/E$

or Amps = Watts ÷ Volts

E =



or $E = P/I$

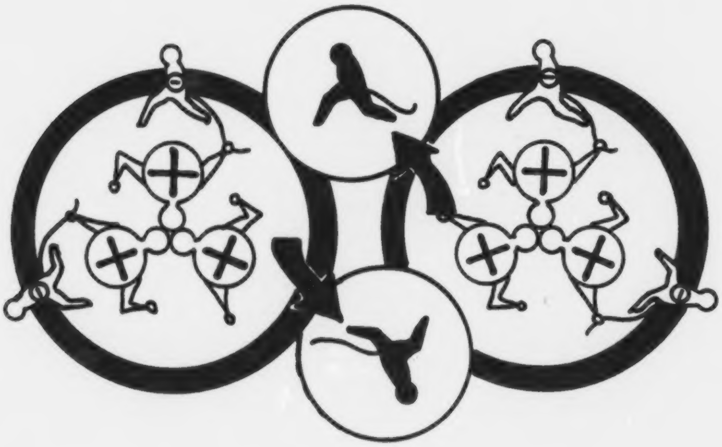
or Volts = Watts ÷ Amps

Basic Theory
Unit 8

Information Sheet

1. **Terms and definitions**
    a. **Amp (ampere)** — Unit of measure of the intensity of the electron flow in a circuit
    b. **Electricity** — Invisible energy
    c. **Electron flow** — Electrons transferring from one atom to another
    d. **Ohm** — Unit of measure of the opposition to electron flow in a circuit
    e. **Volt** — Unit of measure of electromotive force or potential difference
    f. **Watt** — Unit of measure of the power of an electric circuit
2. **Principles of electron flow** (Figures 1-5)
    a. Electricity is the flow of one electron to another.

Figure 1

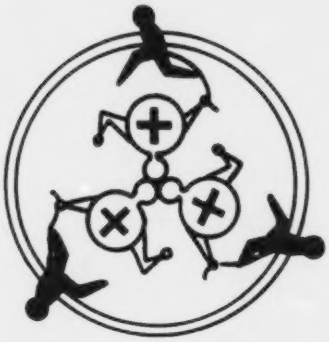


Courtesy of AAVIM

Information Sheet

b. Atoms contain both protons and electrons.

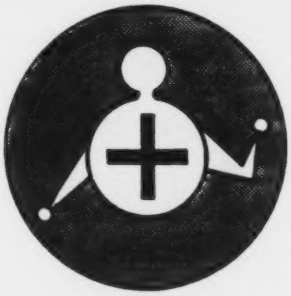
Figure 2



Courtesy of AAVIM

c. Protons always have a positive charge.

Figure 3

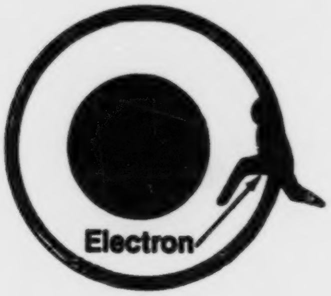


Courtesy of AAVIM

Information Sheet

d. Electrons always have a negative charge.

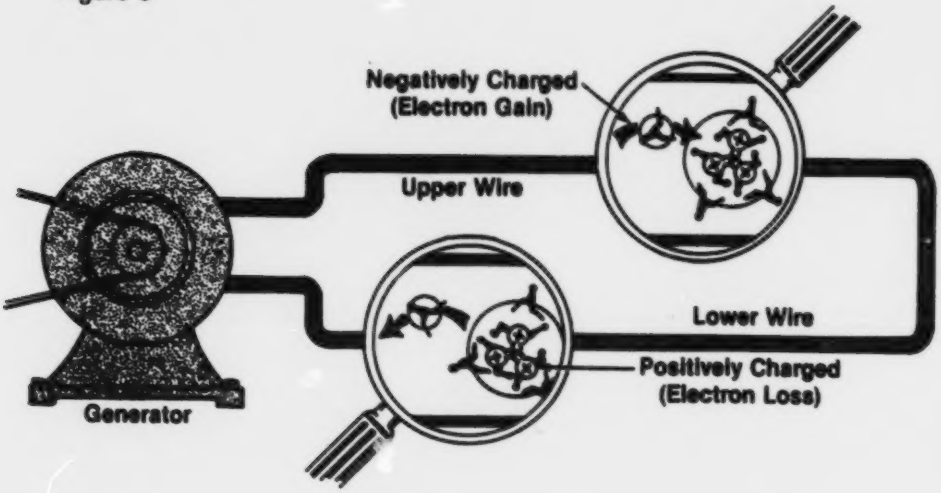
Figure 4



Courtesy of AAVIM

e. Generation occurs when an outside force of power excites the electron flow and electricity is produced.

Figure 5


Negatively Charged
(Electron Gain)
Upper Wire
Lower Wire
Positively Charged
(Electron Loss)
Generator

Courtesy of AAVIM

Information Sheet

3. **Basic sources of electrical generation**

   a. **Friction** produces electricity when two materials are rubbed together.

   Note: This type of electrical generation produces static electricity.

   Example: When you slide your feet across a nylon or wool carpet your shoes develop a charge that is transferred to the body.

   b. **Pressure** produces electricity when pressure is applied to crystalline substances such as quartz or tourmaline.

   Example: A crystal microphone or in a phono cartridge on the pickup arm of a record player

   c. **Heat** produces electricity when it is applied to the junction of two dissimilar metals.

   Example: Thermocouple used in a water heater

   d. **Light** produces electricity when it strikes a photosensitive material.

   Example: Solar cell used on spacecraft

   e. **Chemical action** produces electricity when that action takes place between two metals in a cell.

   Example: Automobile and flashlight batteries

   f. **Magnetism** produces electricity when a magnet is moved past a piece of wire.

   Example: Generator in a power plant or automobile

4. **Distribution of electricity** (Figure 6)

   a. Power is produced at the generating plant.

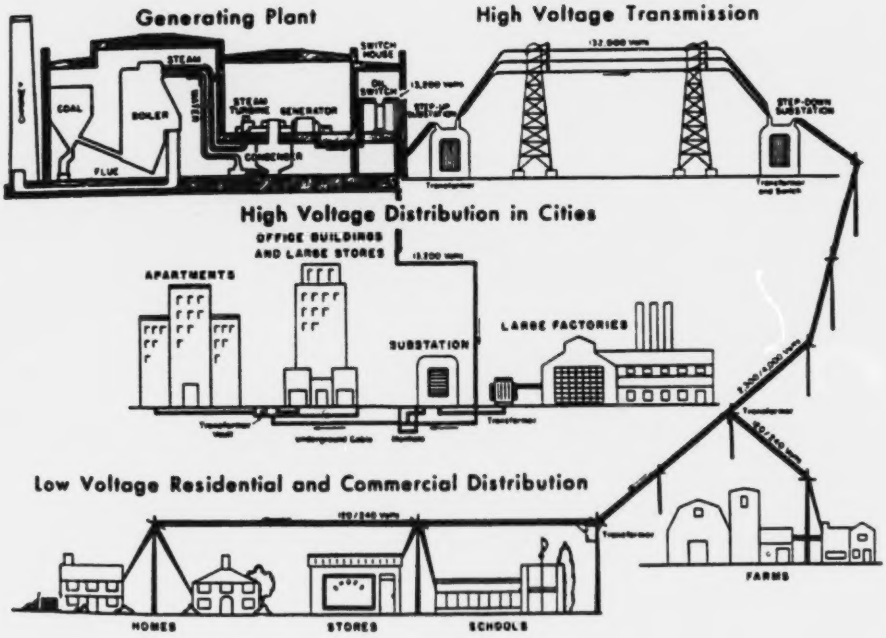
   b. Voltage is stepped up for high-voltage transmission.

   c. Voltage is moved from one area to another through high-voltage transmission lines.

Information Sheet

d. Voltage is stepped down and moved through transformers for public use.

Figure 6

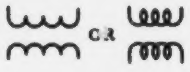

Generating Plant
High Voltage Transmission
SWITCH HOUSE
STEAM
COAL
BOILER
WATER
STEAM TURBINE
GENERATOR
CONDENSER
FLUE
OIL SWITCH
13,200 volts
STEP-UP SUBSTATION
132,000 volts
STEP-DOWN SUBSTATION
Transformer
Transformer and Switch
High Voltage Distribution in Cities
OFFICE BUILDINGS AND LARGE STORES
13,200 volts
APARTMENTS
SUBSTATION
LARGE FACTORIES
Transformer Vault
Underground Cable
Manhole
Transformer
2,300/4,000 volts
Transformer
120/240 volts
Low Voltage Residential and Commercial Distribution
120/240 volts
Transformer
HOMES
STORES
SCHOOLS
FARMS

Reprinted with permission of Bennett Publishing Company.
Industrial Electricity by Rex Miller.

5. **Electrical schematic symbols** (Figures 7-24)

a. Transformer

Figure 7

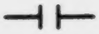


Information Sheet

b. Contacts

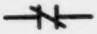
- Normally open

  Figure 8



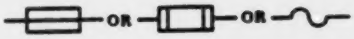
- Normally closed

  Figure 9



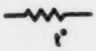
c. Fuse

Figure 10



d. Thermal resistor

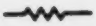
Figure 11



e. Resistor or load

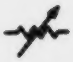
- Fixed

  Figure 12



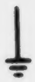
- Variable

  Figure 13



f. Ground connection

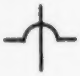
Figure 14



Information Sheet

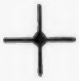
g. Wire crossover

Figure 15



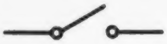
h. Wire connection

Figure 16



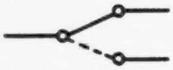
i. Single-pole, single-throw switch

Figure 17



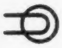
j. Three-way switch

Figure 18



k. Incandescent lamp

Figure 19



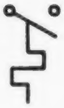
l. Alternating current motor

Figure 20

m. Temperature-activated switch

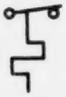
- Closes on rise

Figure 21

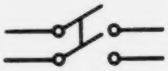


Information Sheet

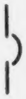
- Opens on rise

  Figure 22 

n. Double-pole, single-throw switch

Figure 23 

o. Circuit breaker

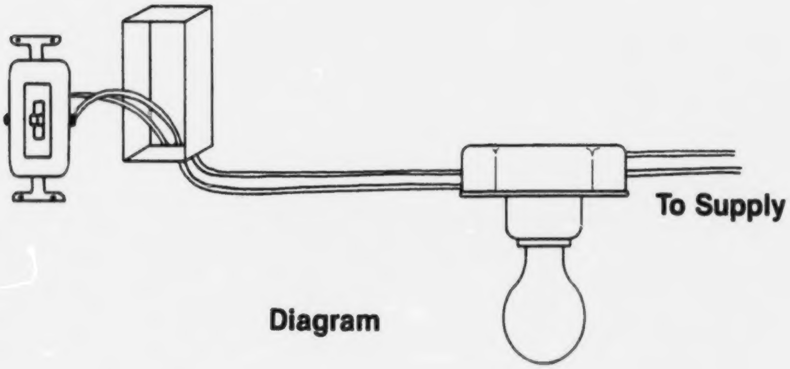
Figure 24 

6. **Diagrams and schematics** (Figures 25 and 26)

a. Diagram

- Drawing-type illustration
- Illustration is of actual equipment and device(s)

Figure 25



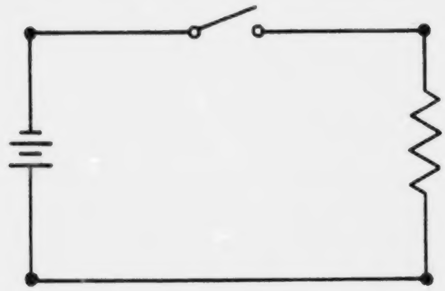
Diagram

Information Sheet

b. Schematic

- Line-type illustration
- Uses standard schematic symbols for equipment and device(s)

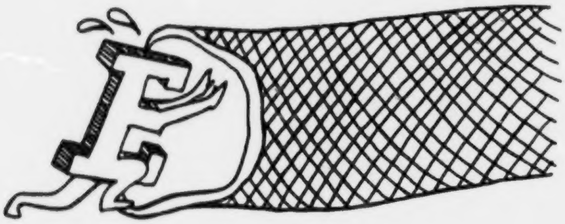
Figure 26



7. **Definitions of electrical abbreviations** (Figures 27-30)

a. **E** — Electromotive force (Emf) in volts

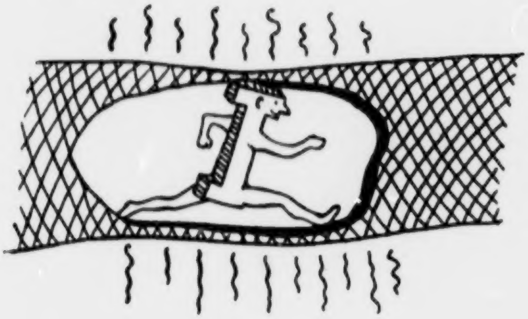
Figure 27



Voltage is pressure, or electromotive force.

b. **I** — Intensity in amps

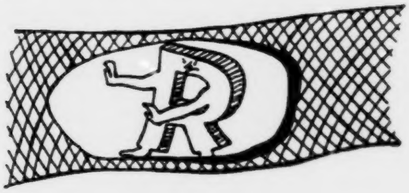
Figure 28



Current is the rate of flow of electrons.

c. **R** — Resistance in ohms

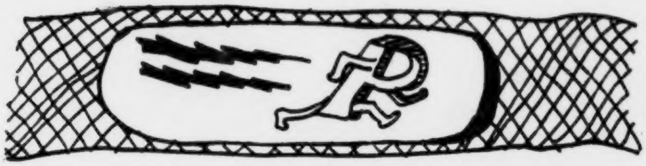
Figure 29



Resistance is opposition to current flow.

d. **P** — Power in watts

Figure 30



Combining volts and amperes produces a measurement of power.

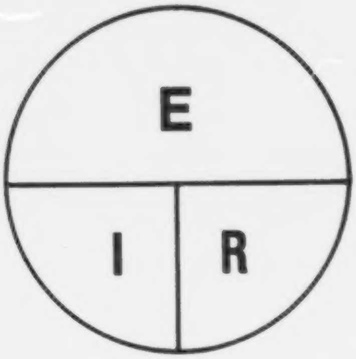
8. **Ohm's law** — The current in an electric circuit equals the pressure (volts) divided by the resistance.

Note: It takes 1 volt to push 1 amp through 1 ohm of resistance.

Information Sheet

9. **Ohm's law in wheel expression** (Figure 31)

Figure 31



10. **Uses of Ohm's law**

    a. Calculating circuit resistance

    b. Calculating circuit amperage

    c. Calculating circuit voltage

Information Sheet

11. Formulas from Ohm's law (Figures 32-34)

Note: When you cover the unknown in the wheel representation of Ohm's law, the remaining letters give you the problem solving equation.

Figure 32: Volts = Amps × Ohms or E = I × R

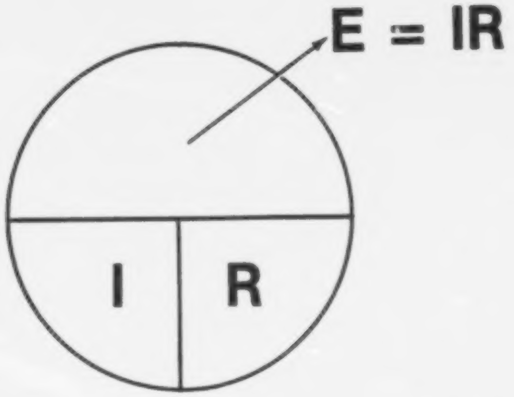


Figure 33: Amps = Volts ÷ Ohms or I = E/R

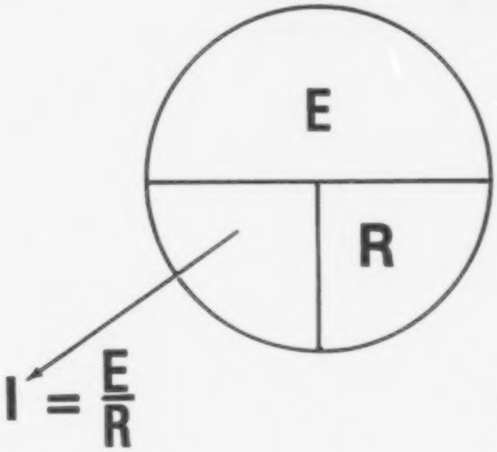
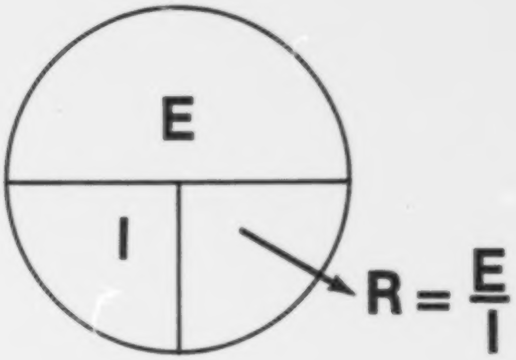


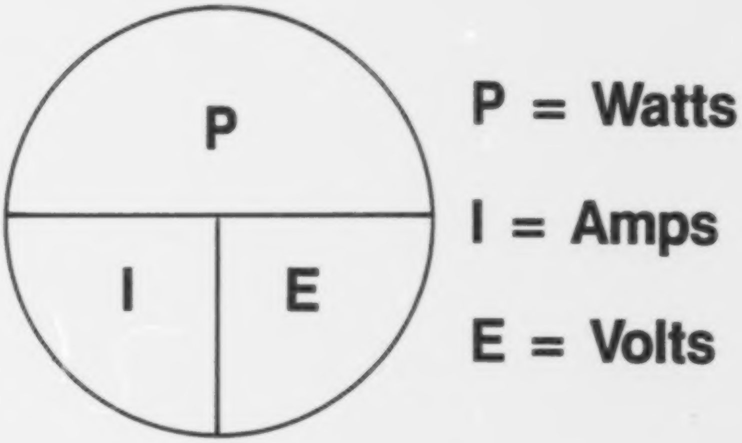
Figure 34: Ohms = Volts ÷ Amps or R = E/I



12. **Ohm's law for power** — The power in an electrical circuit equals the current (amperes) multiplied by the electromotive force (volts).

13. **Ohm's law for power in wheel expression** (Figure 35)

Figure 35


P
I
E
P = Watts
I = Amps
E = Volts

Information Sheet

14. **Uses of Ohm's law for power**
    a. Calculating circuit wattage
    b. Calculating circuit voltage
    c. Calculating circuit amperage

15. **Formulas from Ohm's law for power** (Figures 36-38)

Figure 36: Watts = Amps × Volts or P = I × E

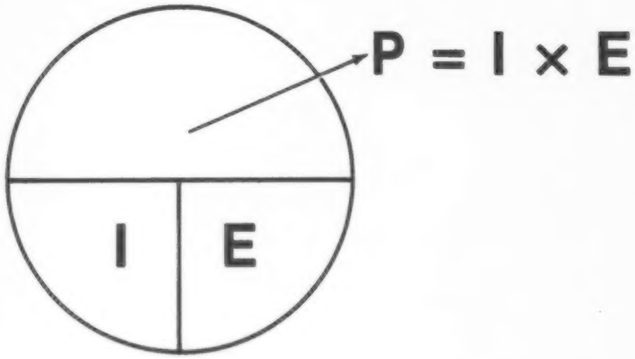
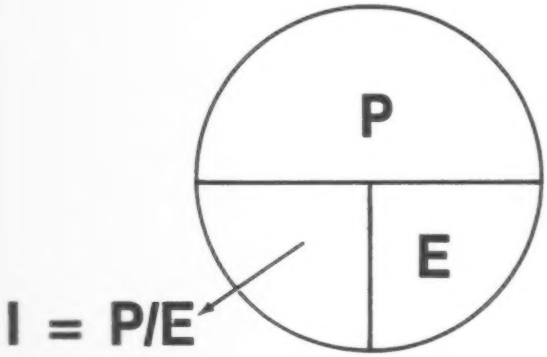
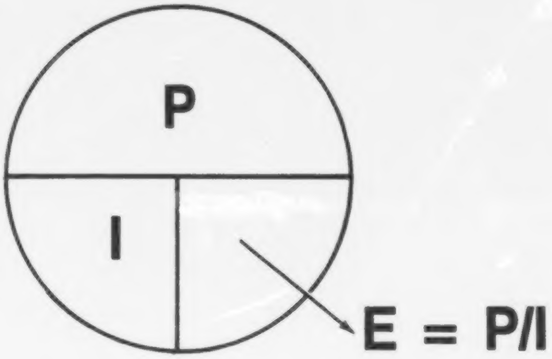


Figure 37: Amps = Watts ÷ Volts or I = P/E



Information Sheet

Figure 38: Volts = Watts + Amps or E = P/I



Basic Theory
Unit 8

Assignment Sheet 1—Draw a Diagram of the Power Distribution Supplying Your School Shop

Name ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
Accurate	______
Neat	______
Correctly labeled	______

Directions: Draw a diagram showing the power distribution supplying your school shop. Refer to Objective 4 for assistance in completing this assignment.

Basic Theory
Unit 8

Assignment Sheet 2—Solve Problems for Unknown Voltage

Name ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
Assignment answers complete	______
Eight of ten answers correct per Answers to Assignment Sheet 2	______

Directions: Apply the appropriate formula from Ohm's law to find the voltage. Show calculations beside each problem.

Example 1: 2 amps, 60 Ohms = ____________ volts
Answer: 2 × 60 = 120

Example 2: 2 amps, 240 watts = ____________ volts
Answer: 240 ÷ 2 = 120

Problems:

	Amps	Ohms		Calculations	Volts
A.	20	6	=		______
B.	4	60	=		______
C.	9.6	2.5	=		______
D.	5	2.4	=		______
	Amps	Watts			
E.	6	1,380	=		______
F.	6.5	715	=		______
G.	2.5	1,100	=		______
H.	5	600	=		______
I.	7	805	=		______
J.	4	500	=		______

Basic Theory
Unit 8

Assignment Sheet 3—Solve Problems for Unknown Amperage

Name ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
Assignment answers complete	______
Eight of ten answers correct per Answers to Assignment Sheet 3	______

Directions: Apply the appropriate formula to find the amperage. Show calculations beside each problem.

Example 1: 120 volts, 40 ohms = ____________ amps
Answer: 120 ÷ 4 = 30

Example 2: 120 watts, 120 volts = ____________ amps
Answer: 120 ÷ 120 = 1

Problems:

	Volts	Ohms		Calculations	Amps
A.	230	12	=		______
B.	110	11	=		______
C.	440	20	=		______
D.	120	40	=		______
E.	24	3	=		______
	Watts	Volts			
F.	6,000	120	=		______
G.	2,640	240	=		______
H.	8,800	440	=		______
I.	690	115	=		______
J.	2,760	230	=		______

Basic Theory
Unit 8

Assignment Sheet 4—Solve Problems for Unknown Resistances and Wattages

Name ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
Assignment answers complete	______
Eight of ten answers correct per Answers to Assignment Sheet 4	______

Directions: Apply the appropriate formula to solve the problems. Show calculations beside each problem.

Example 1: 440 volts, 10 amps = ____________ ohms
Answer: 440 + 10 = 44

Example 2: 115 volts, 12 amps = ____________ watts
Answer: 115 × 12 = 1,380

Problems:

	Volts	Amps		Calculations	Ohms
A.	240	4	=		______
B.	24	9.6	=		______
C.	12	5	=		______
D.	230	5	=		______
E.	24	8	=		______
	Volts	Amps			Watts
F.	240	11	=		______
G.	115	6	=		______
H.	440	20	=		______
I.	230	50	=		______
J.	24	.5	=		______

Basic Theory
Unit 8

Assignment Sheet 5—Solve Problems for an Unknown Quantity

Name ____________________ Overall Rating __________

Evaluation criteria	**Rating**
Assignment answers complete	______
Eight of ten answers correct per Answers to Assignment Sheet 5	______

Directions: Apply the appropriate formula from Ohm's Law to determine the correct voltage in the following problems. Show your calculations.

Example 1: A circuit is drawing a current of 2 amps, and the resistance is 60 Ohms. What is the voltage?

Answer: E = I x R
= 2 x 60
= 120 volts

Example 2: What is the resistance in a circuit drawing 4 amps through a potential of 240 volts?

Answer: R = E/I
= 240/4
= 60 ohms

A. If a 2.5-ohm circuit pulls 9.6 amperes, what is the voltage? ____________

B. A 460-volt circuit operates at 100 amperes. What is the resistance of this circuit? ____________

Assignment Sheet 5

C. A 12-volt circuit is operating a 2.5 amps. What is the power dissipated by the circuit?

____

D. The total resistance of a circuit is 500 ohms, and the total current is 0.500 amps. What is the voltage potential? ____________

E. If a circuit's power is 100 watts and the voltage is 120, what is the current draw?

____

F. How much power is produced by 208 volts at 600 amps? ____________ How much is the resistance of this circuit? ____________

Assignment Sheet 5

G. If a 50-volt circuit dissipates 20 watts of power, what is the total resistance of the circuit? ____________

H. At what current level will 2,200 ohms at 10 volts operate? ____________ How much power will be consumed? ____________

I. A potential difference of 100 volts will produce 100 watts in a circuit. What will be the resistance to the current flow? ____________

J. If 1,000 amperes are flowing in a 480-volt circuit, what is the total resistance? ____________ How much power is being consumed? ____________

DC Circuits
Unit 9

Objective Sheet

Unit Objective

After completing this unit, the student should be able to use Ohm's and Kirchoff's laws to solve problems for unknown current, resistance, and voltage in DC circuits. The student should demonstrate these competencies by completing the assignment sheets and scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to DC circuits with their correct definitions.
2. List applications of DC circuits.
3. State the application of Ohm's law to direct current.
4. Select true statements about characteristics of series circuits.
5. Complete the three basic formulas for Watt's law.
6. State Kirchoff's voltage law.
7. Select true statements about characteristics of parallel circuits.
8. State Kirchoff's current law.
9. Complete statements about characteristics of series-parallel circuits.
10. Select facts about magnetism.
11. Solve problems for unknown current. (Assignment Sheet 1)
12. Solve problems for unknown resistance. (Assignment Sheet 2)
13. Solve problems for unknown voltage. (Assignment Sheet 3)
14. Determine total resistance in series circuits. (Assignment Sheet 4)
15. Determine unknown resistor values in series circuits. (Assignment Sheet 5)

Objective Sheet

16. Solve problems for unknown current in series circuits. (Assignment Sheet 6)

17. Solve problems for unknown resistance in series circuits. (Assignment Sheet 7)

18. Solve problems for unknown voltage in series circuits. (Assignment Sheet 8)

19. Apply Kirchoff's voltage law to series circuits. (Assignment Sheet 9)

20. Solve problems for unknown resistance in parallel circuits. (Assignment Sheet 10)

21. Solve problems for unknown current in parallel circuits. (Assignment Sheet 11)

22. Apply Kirchoff's current law to parallel circuits. (Assignment Sheet 12)

23. Solve problems for unknown resistance in series-parallel circuits. (Assignment Sheet 13)

24. Solve problems for unknown voltage in series-parallel circuits. (Assignment Sheet 14)

25. Solve problems for unknown current in series-parallel circuits. (Assignment Sheet 15)

26. Compute power using Ohm's law. (Assignment Sheet 16)

DC Circuits
Unit 9

Suggested Activities

Instructional Plan

Preparation

1. Read the unit carefully and plan for instruction. Study the specific objectives to determine the order in which you will present them.

2. Review Teaching Suggestions section that follows. Plan for classroom activities.

3. Plan your presentation to take advantage of student learning styles and to accommodate special needs students.

4. Make transparencies from the transparency masters included with this unit. The masters appear in the teacher guide only and are intended to be used with the following objectives:

   TM 1—Series Circuit (Objective 4)
   TM 2—Applying Watt's Law (Objective 5)
   TM 3—Parallel Circuit (Objective 6)

5. Obtain films, videotapes, and other resources to supplement instruction of this unit. See ordering information in the Suggested Supplemental Resources section that follows.

6. Develop teaching plan. Adjust for different learning styles.

7. Make copies of Unit Evaluation Form.

Delivery and Application

8. Provide students with unit of instruction.

9. Discuss unit and specific objectives.

10. Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic skills when applicable.

11. Discuss the assignment sheets and schedule due dates. Review criteria for evaluation of these activities.

Suggested Activities

Evaluation

12. Discuss the use of the Unit Evaluation Form with students. Select and discuss the rating scale that will be used for student evaluation.

13. Make copies of the written test. Add or modify test items as needed.

14. Give written test.

15. Compile assignment sheet ratings and written test scores on the Unit Evaluation Form. Include any additional assignments.

16. Reteach and retest as required.

Teaching Suggestions

Note: Skill areas appearing in boldface type in the Teaching Suggestions refer to the academic and workplace skills identified by the American Society for Training and Development (ASTD) and the U.S. Department of Labor. These have been adapted by MAVCC.

1. Have students work DC circuits on the chalkboard. Skill areas: **Math, writing, problem solving**

2. Set up a display of various resistors and explain their functions. Skill area: **Listening**

3. Demonstrate the principles of magnetism. electromagnetism, and polarity, and explain their relationship to electricity. Skill areas: **Science, math**

Resources Used in Developing This Unit

1. Adams/Rockmaker. *Industrial Electricity*. Brooklyn, NY: McGraw-Hill Book Company, 1985.

2. *DC Fundamentals Review*. Rockville, MD: NUS Training Corporation, a Halliburton Company.

3. *Electromagnetic Induction Review*. Rockville, MD: NUS Training Corporation, a Halliburton Company.

4. Vorderstrasse, Ron. *General Electronics Technician*. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1986.

Suggested Supplemental Resources

1. Viedeotapes

    a. *Symbols, Diagrams, and Circuits*, VHS, 13 minutes. Bergwall Productions, Inc., 540 Baltimore Pike, Chadds Ford, PA 19317. Phone (800) 645-3565.

Suggested Activities

b. *Ohm's Law in Action*, VHS, 15 minutes. Bergwall Productions, Inc., 540 Baltimore Pike, Chadds Ford, PA 19317. Phone (800) 645-3565.

2. Software — *Career Tests: Basic Electricity and Electronics*, IBM. EBSCO Curriculum Materials, P.O. Box 281, Chelsea, AL 35043-0281. Phone (800) 633-8623.

3. Book — Crost, Terrell, ed. *American Electrician's Handbook*, 11th ed. New York: McGraw-Hill, 1987.

Instructions for Evaluating Student Performance

Assignment Sheets—Be sure the student understands the criteria on which the evaluation is based. Assign a point value to each criterion and convert the total points to a percentage for grading.

> Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily achieved the step(s) for each checkpoint area. If the student is unable to correctly complete the procedure, have the student review the materials and try again.
>
> Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria which have been provided as part of the job sheet. Complete the rating by assigning a point value to each criterion and by converting the point total to a percentage for grading. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) which best fits your program needs.

Option A

4 - Skilled—Can perform job with no additional training.
3 - Moderately skilled—Has performed job during training program; limited additional training may be required.
2 - Limited skill—Has performed job during training program; additional training is required to develop skill.
1 - Unskilled—Is familiar with process, but is unable to perform job.

Option B

Yes—Can perform job with no additional training.

No—Is unable to perform job satisfactorily.

DC Circuits
Unit 9

Answers to Assignment Sheets

Assignment Sheet 1

A. .25A
B. .8A
C. .6A
D. 2A
E. .89A

Assignment Sheet 2

A. 6Ω
B. 24Ω
C. 6.66Ω
D. 24Ω
E. 80Ω

Assignment Sheet 3

A. 500V
B. 800V
C. 1200V
D. 2800V
E. 800V

Assignment Sheet 4

A. 85Ω
B. 155Ω
C. 280Ω
D. 200Ω
E. 115Ω

Assignment Sheet 5

A. 15Ω
B. 50Ω
C. 30Ω
D. 20Ω
E. .6Ω

Assignment Sheet 6

A. 1.2A
B. .66A
C. .8A
D. .64A
E. .15A

Assignment Sheet 7

A. 13.33Ω
B. 2.4Ω
C. 2.4Ω
D. 80Ω
E. 10Ω

Assignment Sheet 8

A. 10V
B. 4V
C. 5V
D. 24V
E. 2.4V

Assignment Sheet 9

A. 20V
B. 5.2V
C. 12.6V
D. 42.3V
E. 34V

Assignment Sheet 10

A. 6.66Ω
B. 14.29Ω
C. 2.28Ω
D. 2.11Ω
E. 1.25Ω

Answers to Assignment Sheets

Assignment Sheet 11

A. 1.05A
B. 1.83A
C. 7.08A
D. 13A
E. 1.83A

Assignment Sheet 12

A. 7.2A
B. 31A
C. 22.9A
D. .45A
E. .62A

Assignment Sheet 13

A. 30Ω
B. 44.44Ω
C. 31.11Ω

Assignment Sheet 14

A. 4V
B. 8V
C. 6V
D. 5V
E. 1V

Assignment Sheet 15

A. 1. Total — 1A
  2. Branch #1 — .8A
  3. Branch #2 — .2A
B. 1. Total — .16A
  2. Branch #1 — .1A
  3. Branch #2 — .06A

Assignment Sheet 16

A. .25W
B. .6W
C. 125W
D. 1.6W
E. 19.6W

DC Circuits
Unit 9

Answers to Written Test

1. a. 8
   b. 2
   c. 17
   d. 13
   e. 7
   f. 5
   g. 1
   h. 4
   i. 3
   j. 16
   k. 11
   l. 15
   m. 12
   n. 6
   o. 9
   p. 10
   q. 14

2. Answer should include any six of the following:

   a. Industrial locations for controls and power
   b. Moving of materials and parts
   c. Home appliances, radio, television, and stereo equipment
   d. Automobile and truck systems
   e. Telephone and communications circuits
   f. Computers and electronic equipment
   g. Airplane control and power systems
   h. Medical field
   i. Power for electric carts and battery charges

3. Ohm's law may be used for computing current, resistance, and voltage. Formulas are expressed as:

   Current (I) = E/R
   Resistance (R) = E/I
   Voltage (E) = I × R

4. a, d

5. a. I (amperes
   b. I^2 (amperes)
   c. R (ohms)

6. The sum of the individual voltage drops in a series circuit is equal to the applied voltage.

7. b, d, e

8. The sum of the currents through the individual branches of a parallel circuit is equal to the total current of the circuit.

9. a. Connected
   b. Series resistances
   c. Redraw
   d. Parallel

10. d, f

DC Circuits
Unit 9

Written Test

Name ______________________________ Score ______________

1. Match terms related to DC circuits with their correct definitions. Write the correct numbers in the blanks. Definitions are continued on the next page.

______a. A mathematical expression used to find unknowns

______b. A complete path for current to flow from the source through the load and back to the source

______c. Reduction in circuit potential difference due to resistance

______d. Opposition to electron flow in a conductor or circuit

______e. Power around a magnet

______f. Molecules that act as small magnets when arranged end to end

______g. Measurement of the rate of flow of current through a conductor

______h. Abbreviation for direct current

______i. Materials that permit the free flow of electrons

______j. The measurement of the potential difference between conductors in a circuit

______k. When magnetism leaves a body north and enters south

______l. A circuit that contains some components in series and some in parallel

1. Amperage
2. Circuit
3. Conductors
4. DC
5. Domains
6. Electromagnet
7. Flux lines
8. Formula
9. Magnetism
10. Parallel circuit
11. Polarity
12. Power
13. Resistance
14. Series circuit
15. Series-parallel circuit
16. Voltage
17. Voltage drop

Written Test

______m. Rate of consumption of energy

______n. A magnet made by winding a conductor around a metal core with voltage applied

______o. Property of by certain materials that exerts a mechanical force on other magnetic materials, and can cause induced voltage in conductors when relative movement is present

______p. A circuit that provides more than one path for current flow

______q. A circuit that provides only one path for current flow

2. List six applications of DC circuits.

a. ____

b. ____

c. ____

d. ____

e. ____

f. ____

3. State the application of Ohm's law to direct current

____

____

____

Written Test

4. Select true statements about characteristics of series circuits. Write an "X" in the blank before each true statement.

______a. Current in a series circuit flows only one way through components connected end-to-end, forming a continuous loop and returning to the power source.

______b. Should an open occur in any circuit component, current stops flowing to that load but continues flowing through other paths and their loads.

______c. When current travels through a resistor, the voltage drop across each resistor is equal to the current divided by the resistance ($E = I/R$).

______d. In a series circuit, the formula ($R_1 = R_t - R_2 - R_3$) may be used to find an individual resistance if the total resistance and the resistances of the other components are known.

5. Complete the three basic formulas for Watt's law. Write in the blanks the letters, numbers, or words that best complete each formula.

a. P (in watts) = E (volts) × ________________

b. P (in watts) = ________________ × R (ohms)

c. P (in watts) = $\dfrac{E^2 \text{ (volts)}}{\rule{3cm}{0.4pt}}$

6. State Kirchoff's voltage law.

____

____

7. Select true statements about characteristics of parallel circuits. Write an "X" in the blank before each true statement.

______a. Current in a parallel circuit has only one path flow but carries the load across two or more branch circuits; voltage varies throughout the circuit.

______b. Voltage drop in a parallel circuit is the drop over the entire circuit; the voltage remains the same throughout the entire system.

______c. Total resistance in a parallel circuit is always more than any branch resistance.

Written Test

______d. Reciprocals are any fraction turned upside down.

______e. When voltage and the resistance of each branch are known, the branch currents may be calculated by Ohm's law.

______f. Should an open occur in any circuit component, the current stops flowing through the circuit and to all loads.

8. State Kirchoff's current law.

____

____

____

9. Complete the following statements about characteristics of series-parallel circuits. Write in the blanks the words that best complete each statement.

   a. A series-parallel circuit is a circuit used with both series circuits and parallel circuits __________________.

   b. Step 1 in finding resistance in series-parallel circuits is to calculate the total resistance for the circuit and add together the __________________ in each branch.

   c. Step 2 is to __________________ the circuit to use only one resistance in each branch.

   d. The resistance for the circuit may now be calculated by combing the __________________ resistances.

10. Select facts about magnetism. Write an "X" in the blank before each true statement.

______a. There are three basic kinds of magnets.

______b. Electromagnets are made from rocks and minerals.

______c. A magnet is composed of lines of power, called domains, around the magnetic field.

______d. Magnetic flux lines have four magnetic fields.

______e. When the north pole is put to the south pole, they repel.

______f. Current flow in a conductor produces magnetic lines of force around the conductor.

***Permission to duplicate this test is granted.**

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DC Circuits
Unit 9

Unit Evaluation Form

Student Name ______________________________ Unit Rating __________

Assignment Sheet 1—Solve Problems for Unknown Current Rating ______

Comments: ____

____

Assignment Sheet 2—Solve Problems for Unknown Resistance Rating ______

Comments: ____

____

Assignment Sheet 3—Solve Problems for Unknown Voltage Rating ______

Comments: ____

____

Assignment Sheet 4—Determine Total Resistance in Series Circuits Rating ______

Comments: ____

____

Assignment Sheet 5—Determine Unknown Resistor Values in Series Circuits Rating ______

Comments: ____

____

Assignment Sheet 6—Solve Problems for Unknown Current in Series Circuits Rating ______

Comments: ____

____

Assignment Sheet 7—Solve Problems for Unknown Resistance in Series Circuits Rating ______

Comments: ____

____

Unit Evaluation Form

Assignment Sheet 8—Solve Problems for Unknown Current in Series Circuits Rating ______

Comments: ____________________

Assignment Sheet 9—Apply Kirchoff's Voltage Law to Series Circuits Rating ______

Comments: ____________________

Assignment Sheet 10—Solve Problems for Unknown Resistance in Parallel Circuits Rating ______

Comments: ____________________

Assignment Sheet 11—Solve Problems for Unknown Current in Parallel Circuits Rating ______

Comments: ____________________

Assignment Sheet 12—Apply Kirchoff's Current Law to Parallel Circuits Rating ______

Comments: ____________________

Assignment Sheet 13—Solve Problems for Unknown Resistance in Series-Parallel Circuits Rating ______

Comments: ____________________

Assignment Sheet 14—Solve Problems for Unknown Voltage in Series-Parallel Circuits Rating ______

Comments: ____________________

Assignment Sheet 15—Solve Problems for Unknown Current in Series-Parallel Circuits Rating ______

Comments: ____________________

Unit Evaluation Form

Assignment Sheet 16—Compute Power Using Ohm's Law Rating ______

Comments: ____

____

Written Test Scores

Pretest ______ Posttest ______ Other ______

Other ____

____

Teacher Signature ______________________________ Date ____________

Student Signature ______________________________ Date ____________

***Permission to duplicate this form is granted.**

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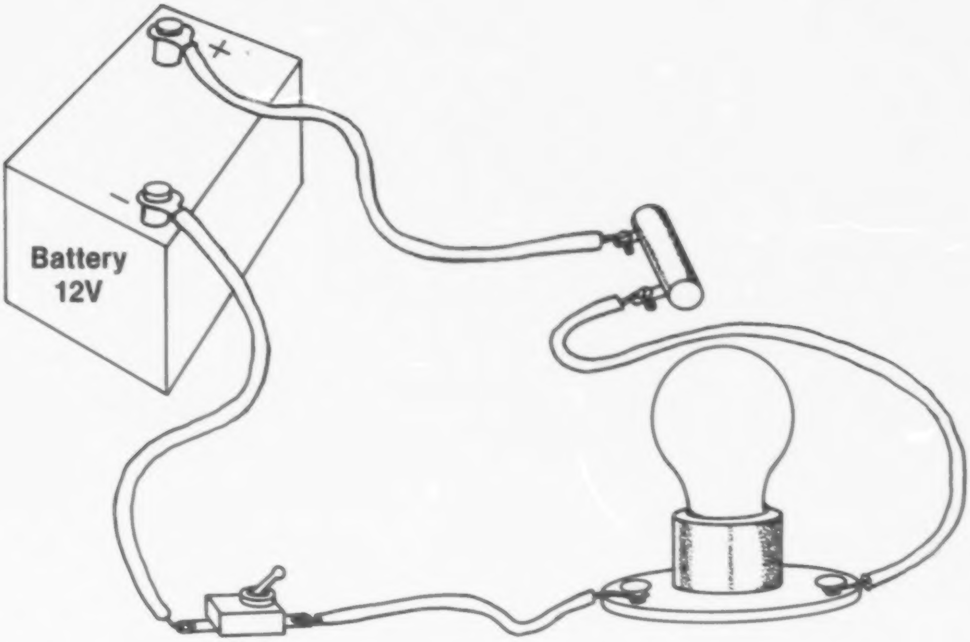
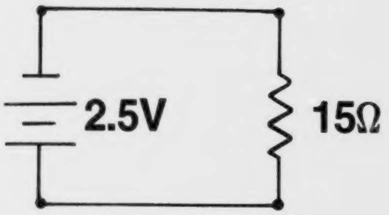
Series Circuit


+
−
Battery
12V

Applying Watt's Law

When Voltage and resistance is known:

$\left(P = \frac{E^2}{R}\right)$



E = 2.5V

R = 15Ω

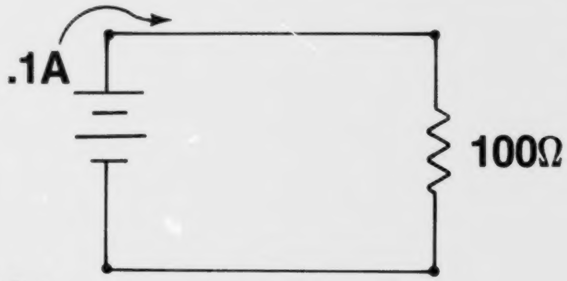
$P = \frac{E^2}{R}$

$P = \frac{(2.5)^2}{15} = \frac{2.5 \times 2.5}{15} = .417\ W$

P = .417 Watt

When current and resistance is known:

$P = I^2 \times R$



R = 100Ω

I = .1A

$P = I^2 \times R$

$P = (0.1)^2 \times 100 = (0.1 \times 0.1) \times 100 = 1\ W$

P = 1 Watt

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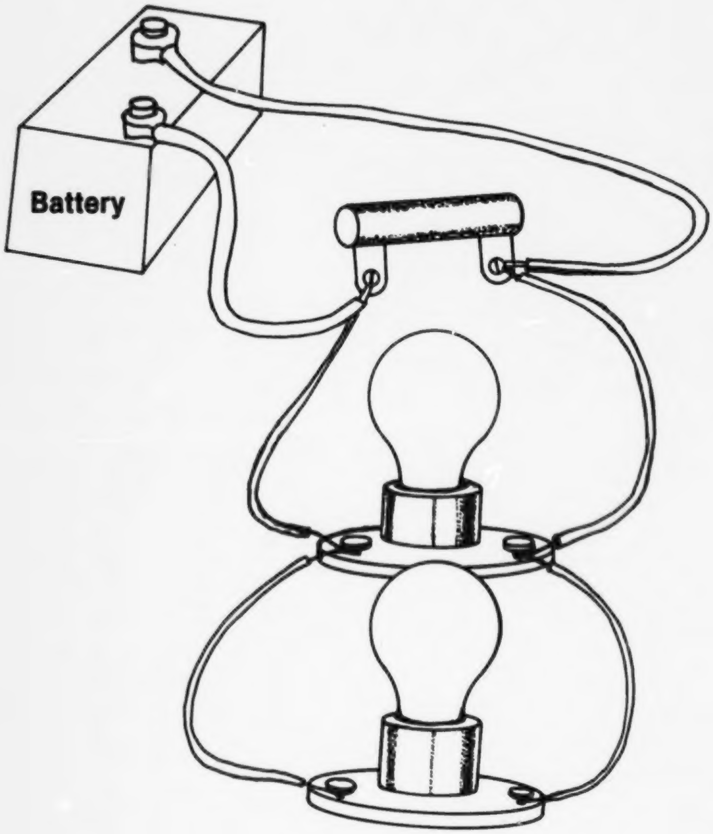
Parallel Circuit



DC Circuits
Unit 9

Information Sheet

1. **Terms and definitions**

   a. **Amperage** — Measurement of the rate of flow of current through a conductor

   b. **Circuit** — A complete path for current to flow from the source through the load and back to the source

   c. **Conductors** — Materials that permit the free flow of electrons

   d. **DC** — Abbreviation for direct current

   e. **Domains** — Molecules that act as small magnets when arranged end-to-end

   f. **Electromagnet** — A magnet made by winding a conductor around a metal core with voltage applied

   g. **Flux lines** — Power around a magnet

   h. **Formula** — A mathematical expression used to find unknowns

   i. **Magnetism** — Property of certain materials that exerts a mechanical force on other magnetic materials, and can cause induced voltage in conductors when relative movement is present

   j. **Parallel circuit** — A circuit that provides only one path for current flow

   k. **Polarity** — When magnetism leaves a body north and enters south

   Example: When using a VOM, the red lead always connects to the positive, and the black lead always connects to the negative.

   l. **Power** — Rate of consumption of energy

   m. **Resistance** — Opposition to electron flow in a conductor or circuit

   Note: Electron flow in a circuit always travels from positive to negative.

   n. **Series circuit** — A circuit that provides more than one path for current flow

   o. **Series-parallel circuit** — A circuit that contains some components in series and some in parallel

   p. **Voltage** — The measurement of the potential difference between conductors in a circuit

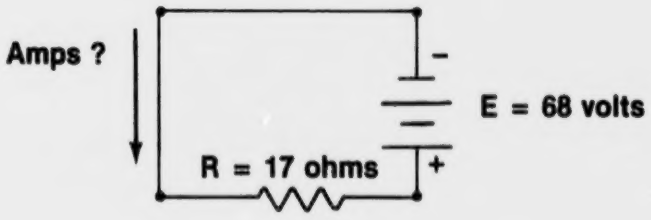
   q. **Voltage drop** — Reduction in circuit potential difference due to resistance

Information Sheet

2. **Applications of DC circuits**
   a. Industrial locations for controls and power
   b. Moving of materials and parts
   c. Home appliances, radio, television, and stereo equipment
   d. Automobile and truck systems
   e. Telephone and communications circuits
   f. Computers and electronic equipment
   g. Airplane control and power systems
   h. Medical field
   i. Power for electric carts and battery charges

3. **Application of Ohm's law to DC** (Figures 1-3)
   a. **Ohm's law for computing current (I)** — I = E/R

Figure 1



$$I = \frac{E}{R}$$

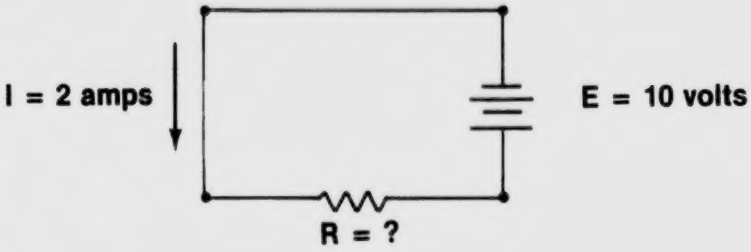
$$= \frac{68V}{17\Omega}$$

$$= 4A$$

Information Sheet

b. **Ohm's law for computing resistance (R)** — R = E/I

Figure 2


I = 2 amps
E = 10 volts
R = ?

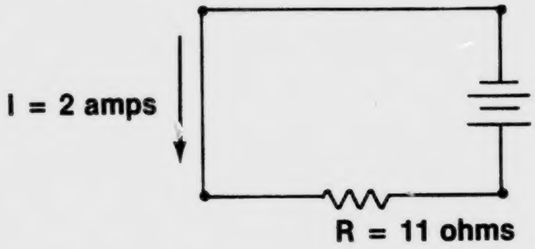
$$R = \frac{E}{I}$$

$$= \frac{10V}{2A}$$

$$= 5\Omega$$

c. **Ohm's law for computing voltage (E)** — E = I × R

Figure 3


I = 2 amps
E = ?
R = 11 ohms

$$E = I \times R$$

$$= 2A \times 11\Omega$$

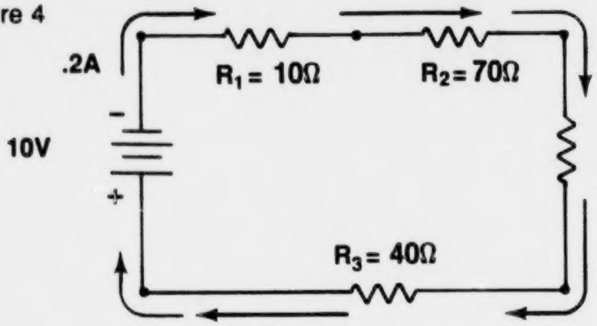
$$= 22V$$

Information Sheet

4. **Characteristics of series circuits** (Figures 4-7)

   a. Current in a series circuit flows only one way through components connected end-to-end, forming a continuous loop and returning to the power source.

   Figure 4



   Note: When voltage and current are known, the total resistance in a series circuit can be calculated using Ohm's law.

$$R = \frac{E}{I}$$

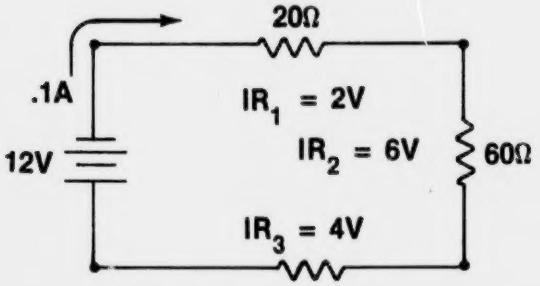
$$= \frac{10V}{.2A}$$

$$= 120\Omega$$

   b. Should an open occur in any circuit component, current stops flowing through the circuit and to all loads.

   c. When current travels through a resistor, the voltage drop across each resistor is equal to the current times the resistance ($E = I \times R$).

   Figure 5



$I_{R_1} = .1A \times 20\Omega = 2V$

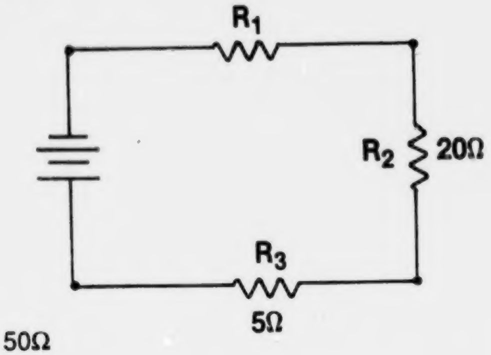
$I_{R_2} = .1A \times 60\Omega = 6V$

$I_{R_3} = .1A \times 40\Omega = 4V$

Information Sheet

d. In a series circuit, the formula ($R_1 = R_t - R_2 - R_3$) may be used to find an individual resistance if the total resistance and the resistances of the other components are known.

Figure 6



$R_t = 50\Omega$

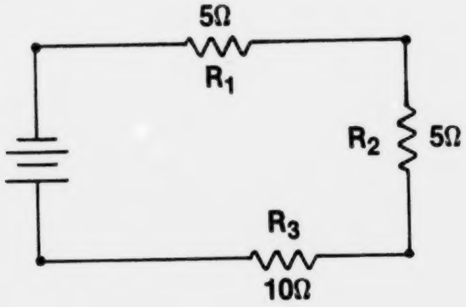
$R_1 = R_t - R_2 - R_3$

$= 50\Omega - 20\Omega - 5\Omega$

$= 25\Omega$

e. When totaling resistances in a series circuit, the sum of each resistance in the circuit can be mathematically stated ($R_t = R_1 + R_2 + R_3$)

Figure 7



$R_t = R_1 + R_2 + R_3$

$= 5\Omega + 5\Omega + 10\Omega$

$= 20\Omega$

Information Sheet

5. **Watt's law** — Power in an electrical circuit may be calculated by using this law, which is expressed by three basic formulas:

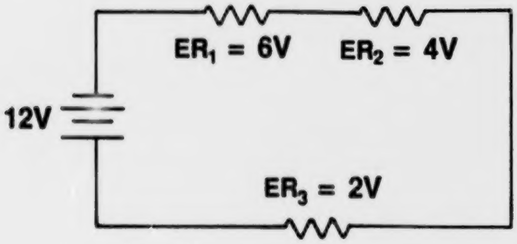
   a. P (in watts) = E (volts) × I (amperes)

   b. P (in watts) = I^2 (amperes) × R (ohms)

   c. P (in watts) = $\frac{E^2 \text{ (volts)}}{R \text{ (ohms)}}$

6. **Kirchoff's voltage law** — The sum of the individual voltage drops in a series circuit is equal to the applied voltage. (Figure 8)

Figure 8



The individual voltage drops are 6 volts, 4 volts, and 2 volts.

$E_t = 12V$

$E_t = E_{R_1} + E_{R_2} + E_{R_3}$

$= 6V + 4V + 2V$

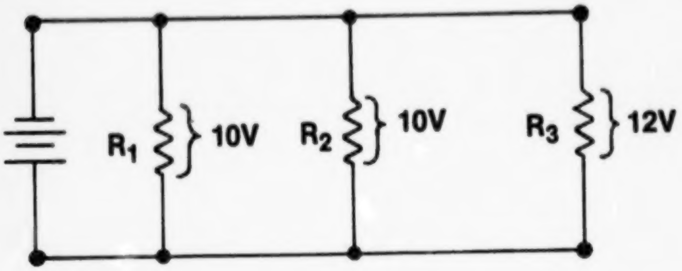
$= 12V$

Information Sheet

7. **Characteristics of parallel circuits** (Figures 9-12)

   a. Current in a parallel circuit travels in more than one path through two or more loads connected across two lines; voltage remains constant throughout the circuit.

   Figure 9



   b. Should an open occur in any one path, current stops flowing through that path, and to the load on that path, but continues flowing through other paths and to their loads.

   c. Voltage drop in a parallel circuit is the drop over the entire circuit. The voltage remains the same throughout the entire system.

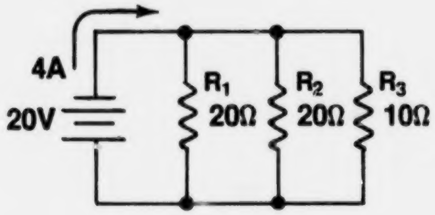
Information Sheet

d. Total resistance in a parallel circuit is always less than any branch resistance. Ohm's law is used to calculate total resistance.

Note: When total current and total voltage are given, total resistance may be calculated as shown in the example.

Example: $R = \frac{E}{I}$

Figure 10



$$\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$= \frac{1}{20} + \frac{1}{20} + \frac{1}{10}$$

$$= \frac{1}{20} + \frac{1}{20} + \frac{2}{20}$$

$$= \frac{4}{20}$$

$$= 5\Omega$$

e. Reciprocals are used in figuring resistance. Reciprocals are any fraction turned upside down.

Example: Reciprocal of 3 is ⅓
Reciprocal of ¾ is ⁴⁄₃

Note: A scientific calculator may be used to simplify the solving of parallel resistance. The solution for the above problem is as follows on the next page.

Information Sheet

SOLUTION

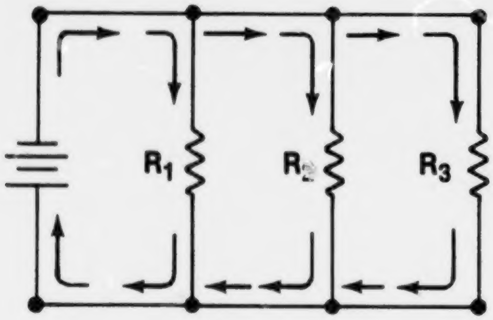
	Keystroke	*Display*
Enter R_1.	2 0	20
Reciprocal	1/X	.05
Store in Memory.	STO	.05
Enter R_2.	2 0	20
Reciprocal	1/X	.05
Add to Memory.	SUM	.05
Enter R_3.	1 0	10
Reciprocal	1/X	.10
Add to Memory.	SUM	.10
Recall the contents of the Memory, which is the sum of the three reciprocals.	RCL	.20
Find reciprocal of the sum (ohms).	1/X	5

Not all scientific calculators will require the same keystrokes. Check your calculator's users' manual for the proper keystrokes. (See your instructor for assistance.)

Information Sheet

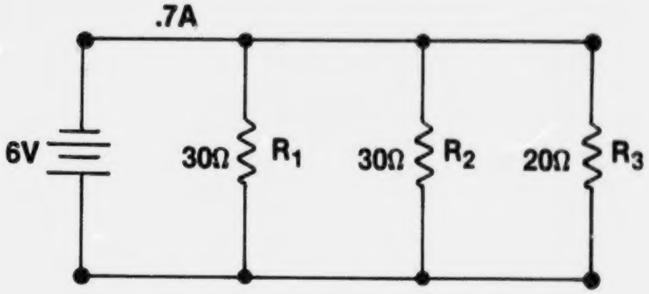
f. Parallel branch circuits differ from series circuits as there are many different paths for the current to follow.

Figure 11



g. When voltage and the resistance of each branch are known, the branch currents may be calculated by Ohm's law (I = E/R)

Figure 12



Calculations for R_1:

$I = \frac{E}{R}$ $\quad I_{R_1} = \frac{E}{R_1}$ $\quad I_{R_1} = \frac{6V}{30\Omega}$ $\quad I_{R_1} = .2$ amps

Calculations for R_2:

$I_{R_2} = \frac{E}{R_2}$ $\quad I_{R_2} = \frac{6V}{30\Omega}$ $\quad I_{R_1} = .2$ amps

Calculations for R_3:

$I_{R_3} = \frac{E}{R_3}$ $\quad I_{R_3} = \frac{6V}{20\Omega}$ $\quad I_{R_1} = .3$ amps

Information Sheet

h. The total of all three branch currents may now be put into a formula for total current.

Example: $I_t = .7A$

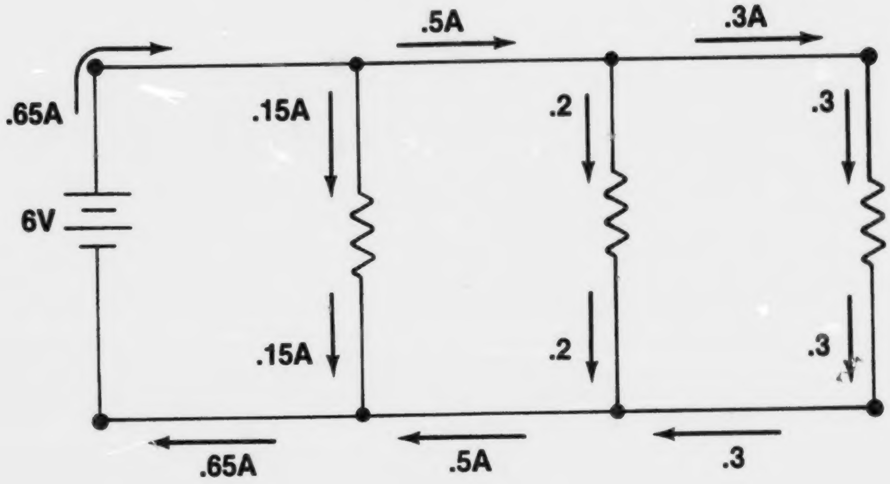
$I_t = I_{R_1} + I_{R_2} + I_{R_3}$

$= .2A + .2A + .3A$

$= .7A$

8. **Kirchoff's current law** — The sum of the currents through the individual branches of a parallel circuit is equal to the total current of the circuit.

Figure 13



$I_t = .65$

$I_t = I_{R_1} + I_{R_2} + I_{R_3}$

$= .15A + .2A + .3A$

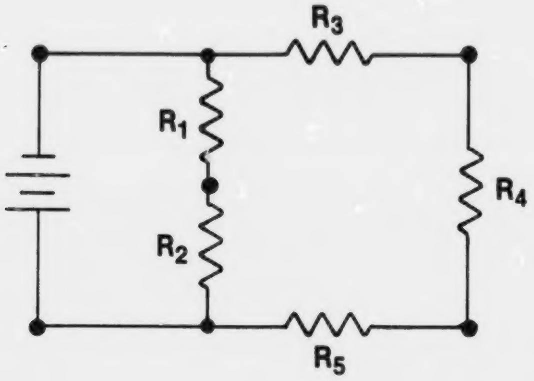
$= .65A$

Information Sheet

9. **Characteristics of series-parallel circuits** (Figures 14-16)

   a. A series-parallel circuit is a circuit used with both series circuits and parallel circuits connected.

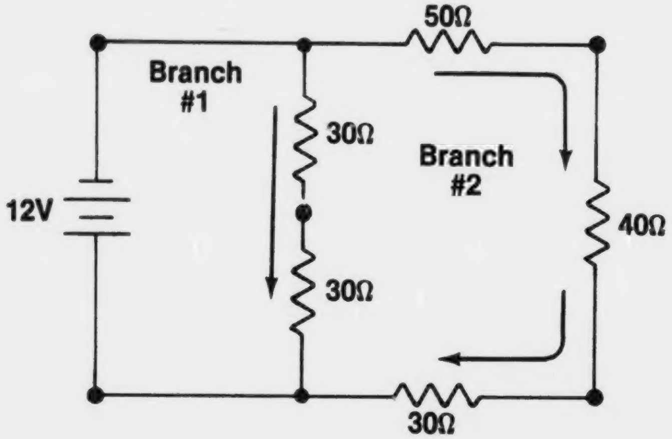
   Figure 14


R_3
R_1
R_4
R_2
R_5

   b. To find resistance in series-parallel circuits requires two steps.

   Note: Series-parallel circuits must be simplified before the values can be calculated.

   Figure 15


50Ω
Branch #1
30Ω
Branch #2
12V
40Ω
30Ω
30Ω

Information Sheet

- Step 1: Calculate the total resistance for the circuit by adding together the series resistances in each branch. In circuit #1 the series resistances are 30Ω and 30Ω.

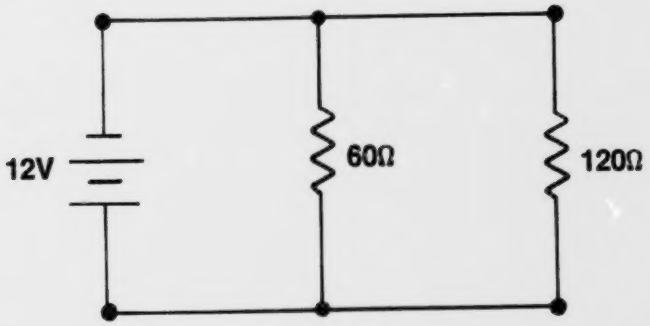
  Formula: R branch #1 = 30Ω + 30Ω
  R branch #1 = 60Ω

  In circuit #2 the series resistances are 50Ω + 40Ω + 30Ω.

  Formula: R branch #2 = 50Ω + 40Ω + 30Ω
  R branch #2 = 120Ω

- Step 2: Redraw the circuit to use only one resistance in each branch.

  Figure 16



- The resistance for the circuit may now be calculated by combining the parallel resistances.

Formula: $R_t = 40$

$$\frac{1}{R_t} = \frac{1}{R_{\text{branch \#1}}} + \frac{1}{R_{\text{branch \#2}}}$$

$$= \frac{2}{120} + \frac{1}{120}$$

$$= \frac{3}{120}$$

$$= \frac{1}{40}$$

$$= 40$$

Information Sheet

Note: A scientific calculator may be used to simplify the solving of circuit resistance.

10. Facts about magnetism

a. There are two basic kinds of magnetism:

- Naturally magnetic minerals called lodestones,
- Electromagnets that are man-made from steel cores with wire windings and are produced by electricity.

b. Molecules, called domains, act as small magnets if properly arranged.

c. A magnet is composed of lines of power, called flux lines, around the magnetic field.

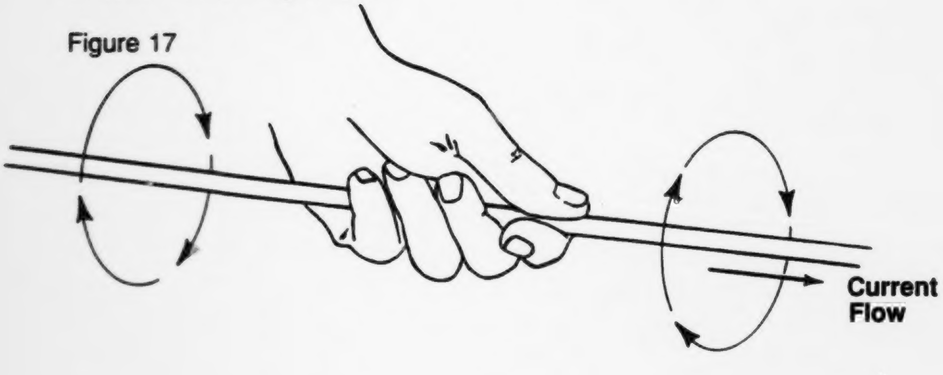
d. Magnetic flux lines have four magnetic fields.

- When the north pole is put to the south pole, they attract.
- When north pole and north pole are aligned, they repel.
- When south pole and south pole are aligned, they repel.
- Magnetic attraction varies with pole strength and distance.

e. Electromagnets are used for iron lifting, and opening contactors, valves, breakers, and relays.

f. The Left-Hand Rule for finding the direction of circulation of magnetic lines of flux states: If you grasp a straight wire with your left hand and point your thumb in the direction of electron flow (negative to positive), your fingers will curl in the direction of the magnetic flux.

Figure 17



DC Circuits
Unit 9

Assignment Sheet 1—Solve Problems for Unknown Current

Name ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
Computed all problems and showed work	______
Labeled answers with correct unit of measurement	______
Computed a minimum of four of the five answers correctly per Assignment Sheet 1 answers	______

Directions: Apply the appropriate formula from Ohm's law to find current in the following problems. Show calculations in the space provided below each problem.

A. In a circuit having a 60-ohm resistor and a voltage of 15 volts, what is the current?

____

B. In a circuit having a 30-ohm resistor and a voltage of 24 volts, what is the current?

____

C. In a circuit having a 20-ohm resistor and a voltage of 12 volts, what is the current?

____

D. In a circuit having a 60-ohm resistor and a voltage of 120 volts, what is the current?

____

E. In a circuit having a 90-ohm resistor and a voltage of 80 volts, what is the current?

____

DC Circuits
Unit 9

Assignment Sheet 2—Solve Problems for Unknown Resistance

Name ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
Computed all problems and showed work	______
Labeled answers with correct unit of measurement	______
Computed a minimum of four of the five answers correctly per Assignment Sheet 2 answers	______

Directions: Apply the appropriate formula from Ohm's law to find current in the following problems. Show calculations in the space provided below each problem.

A. Compute the resistance in a circuit with 12 volts and 2 amps. ____________

B. Compute the resistance in a circuit with 120 volts and 5 amps. ____________

C. Compute the resistance in a circuit with 100 volts and 15 amps. ____________

D. Compute the resistance in a circuit with 24 volts and 1 amps. ____________

E. Compute the resistance in a circuit with 16 volts and .2 amps. ____________

DC Circuits
Unit 9

Assignment Sheet 3—Solve Problems for Unknown Voltage

Name ______________________________ Overall Rating __________

Evaluation criteria	Rating
Computed all problems and showed work	______
Labeled answers with correct unit of measurement	______
Computed a minimum of four of the five answers correctly per Assignment Sheet 3 answers	______

Directions: Apply the appropriate formula from Ohm's law to find current in the following problems. Show calculations in the space provided below each problem.

A. Find the voltage in a circuit having 5 amps and 100 ohms. __________

B. Find the voltage in a circuit having 10 amps and 80 ohms. __________

C. Find the voltage in a circuit having 20 amps and 60 ohms. __________

D. Find the voltage in a circuit having 70 amps and 40 ohms. __________

E. Find the voltage in a circuit having 40 amps and 20 ohms. __________

DC Circuits
Unit 9

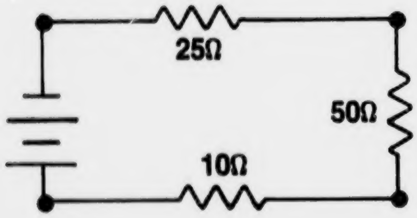
Assignment Sheet 4—Determine Total Resistance in Series Circuits

Name ________________________ Overall Rating __________

Evaluation criteria	**Rating**
Computed all problems and showed work	_____
Labeled answers with correct unit of measurement	_____
Computed a minimum of four of the five answers correctly per Assignment Sheet 4 answers	_____

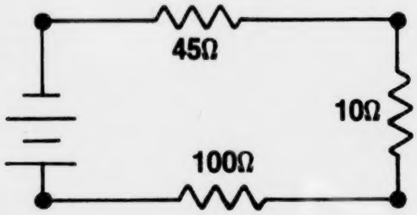
Directions: Determine the total resistance in the following series circuits. Show calculations in the space provided above each answer.

A.



Answer ________________

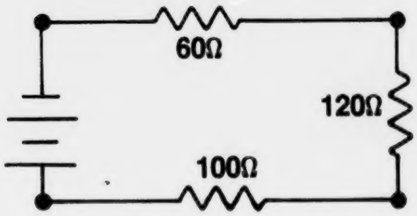
B.



Answer ________________

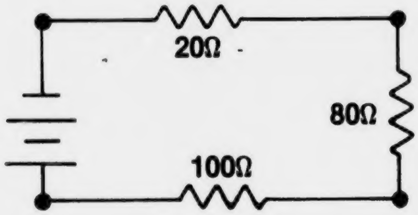
Assignment Sheet 4

C.


60Ω
120Ω
100Ω

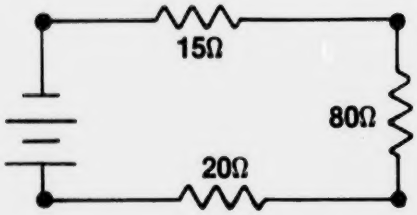
Answer ____________________

D.


20Ω
80Ω
100Ω

Answer ____________________

E.



Answer ____________________

DC Circuits
Unit 9

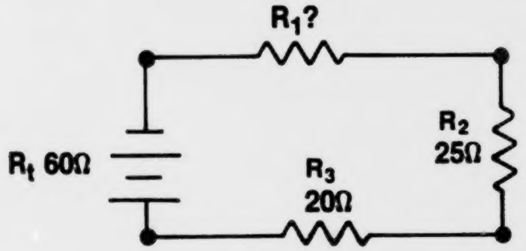
Assignment Sheet 5—Determine Unknown Resistor Values in Series Circuits

Name ______________________________ Overall Rating __________

Evaluation criteria	Rating
Computed all problems and showed work	_____
Labeled answers with correct unit of measurement	_____
Computed a minimum of four of the five answers correctly per Assignment Sheet 5 answers	_____

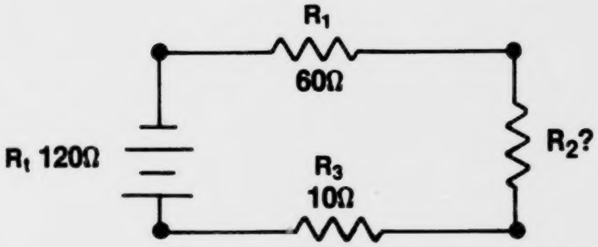
Directions: Study the following schematics and determine unknown circuit values. Show calculations in the space provided above each answer.

A.



Answer ____________________

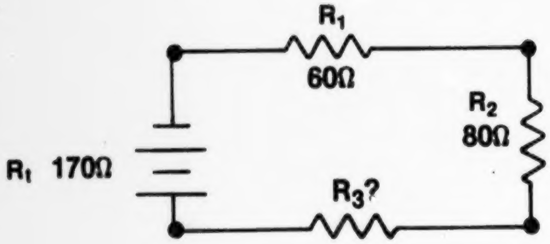
B.



Answer ____________________

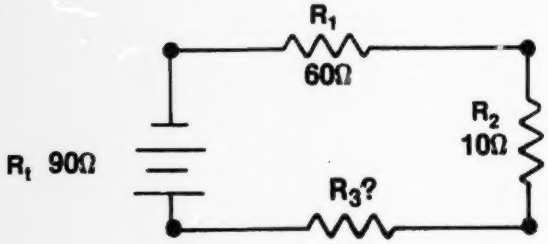
Assignment Sheet 5

C.


R₁
60Ω
R₂
80Ω
Rₜ 170Ω
R₃?

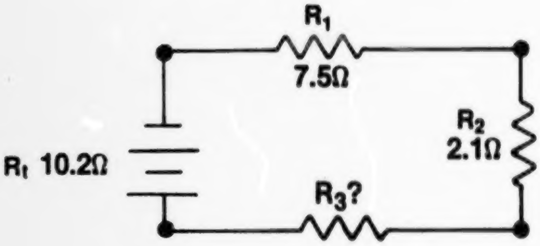
Answer ____________________

D.


R₁
60Ω
R₂
10Ω
Rₜ 90Ω
R₃?

Answer ____________________

E.


R₁
7.5Ω
R₂
2.1Ω
Rₜ 10.2Ω
R₃?

Answer ____________________

DC Circuits
Unit 9

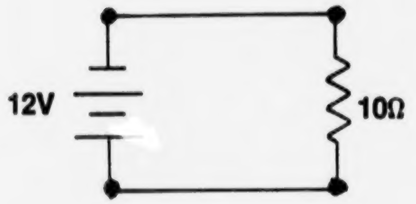
Assignment Sheet 6—Solve Problems for Unknown Current in Series Circuits

Name ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
Computed all problems and showed work	______
Labeled answers with correct unit of measurement	______
Computed a minimum of four of the five answers correctly per Assignment Sheet 6 answers	______

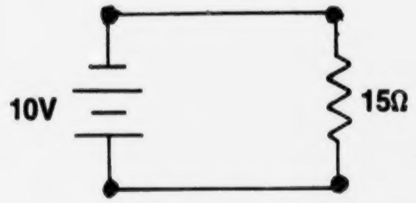
Directions: Apply the appropriate formula from Ohm's law to find the current in the following problems. Show calculations in the space provided above each answer.

A.



Answer ________________

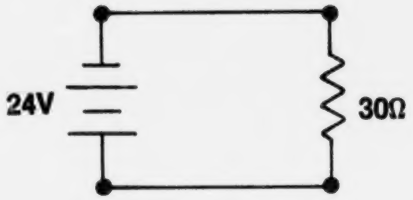
B.



Answer ________________

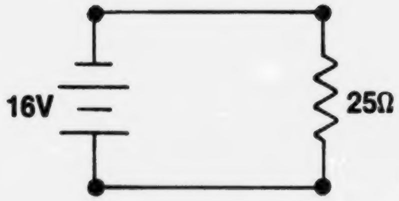
Assignment Sheet 6

C.



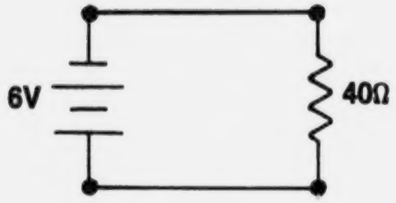
Answer ____________________

D.



Answer ____________________

E.



Answer ____________________

DC Circuits
Unit 9

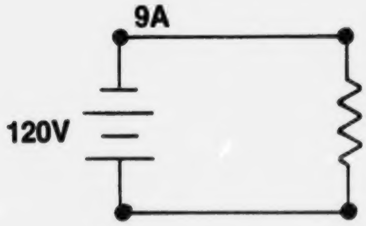
Assignment Sheet 7—Solve Problems for Unknown Resistance in Series Circuits

Name ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
Computed all problems and showed work	______
Labeled answers with correct unit of measurement	______
Computed a minimum of four of the five answers correctly per Assignment Sheet 7 answers	______

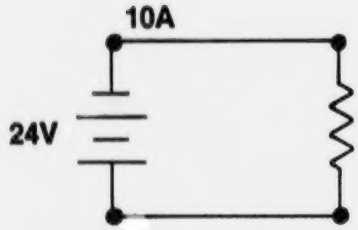
Directions: Apply the appropriate formula from Ohm's law to find resistance in the following series circuits. Show calculations in the space provided above each answer.

A.



Answer ____________________

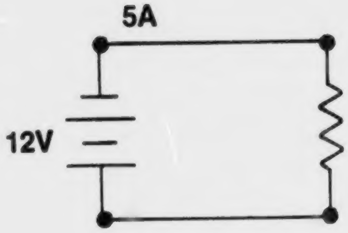
B.



Answer ____________________

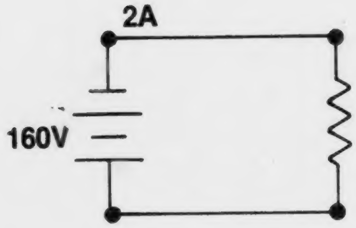
Assignment Sheet 7

C.



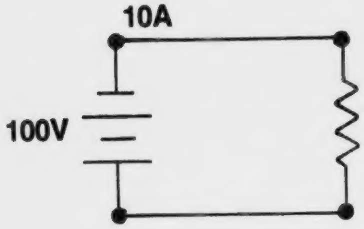
Answer ____________________

D.



Answer ____________________

E.



Answer ____________________

DC Circuits
Unit 9

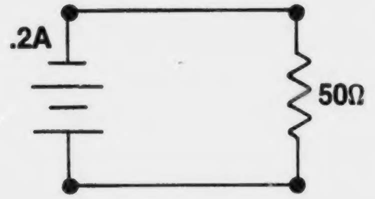
Assignment Sheet 8—Solve Problems for Unknown Voltage in Series Circuits

Name ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
Computed all problems and showed work	_____
Labeled answers with correct unit of measurement	_____
Computed a minimum of four of the five answers correctly per Assignment Sheet 8 answers	_____

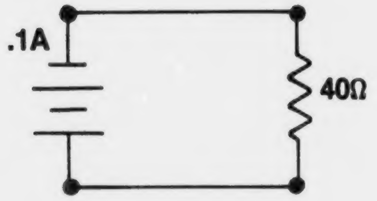
Directions: Apply the appropriate formula from Ohm's law to find voltage in the following series circuits. Show calculations in the space provided above each answer.

A.



Answer ________________

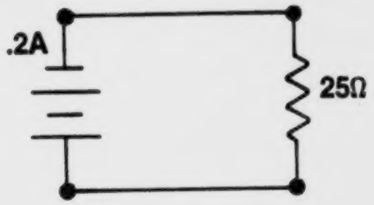
B.



Answer ________________

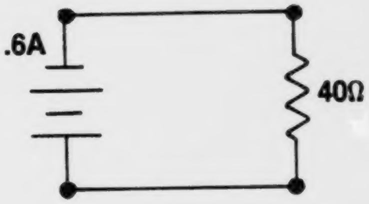
Assignment Sheet 8

C.



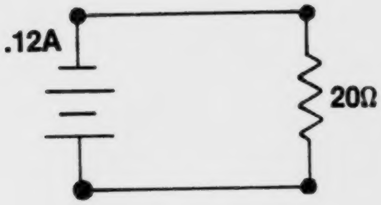
Answer ____________________

D.



Answer ____________________

E.



Answer ____________________

DC Circuits
Unit 9

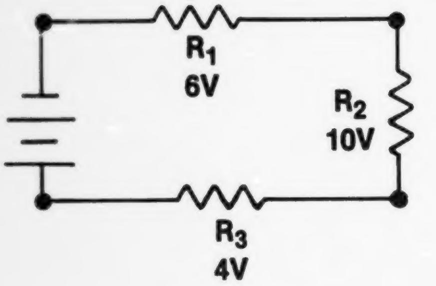
Assignment Sheet 9—Apply Kirchoff's Voltage Law to Series Circuits

Name ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
Computed all problems and showed work	______
Labeled answers with correct unit of measurement	______
Computed a minimum of four of the five answers correctly per Assignment Sheet 9 answers	______

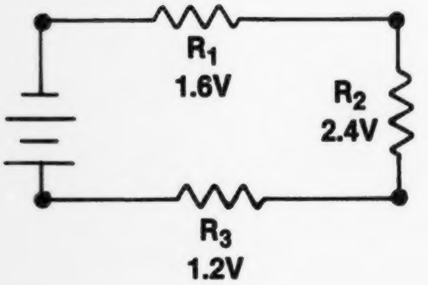
Directions: Using Kirchoff's voltage law, find voltage in the following problems. Show calculations in the space provided above each answer.

A.



Answer ________________

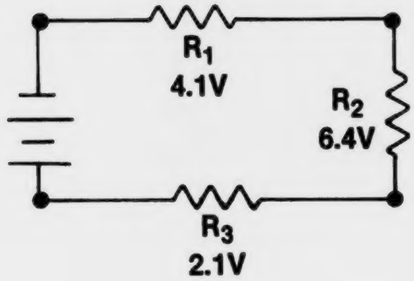
B.



Answer ________________

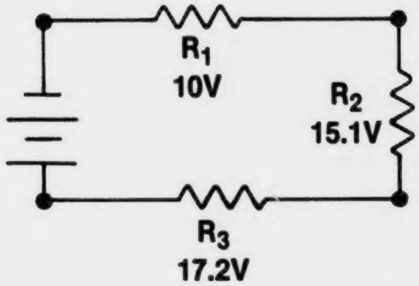
Assignment Sheet 9

C.


R1
4.1V
R2
6.4V
R3
2.1V

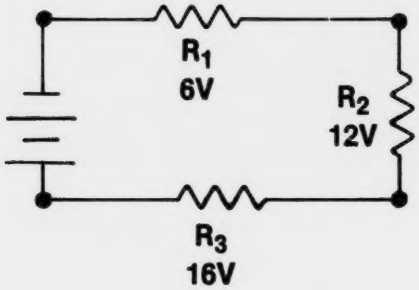
Answer ____________________

D.


R1
10V
R2
15.1V
R3
17.2V

Answer ____________________

E.


R1
6V
R2
12V
R3
16V

Answer ____________________

DC Circuits
Unit 9

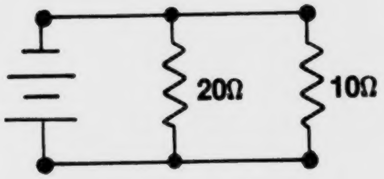
Assignment Sheet 10—Solve Problems for Unknown Resistors in Parallel Circuits

Name ______________________ Overall Rating __________

Evaluation criteria	**Rating**
Computed all problems and showed work	______
Labeled answers with correct unit of measurement	______
Computed a minimum of four of the five answers correctly per Assignment Sheet 10 answers	______

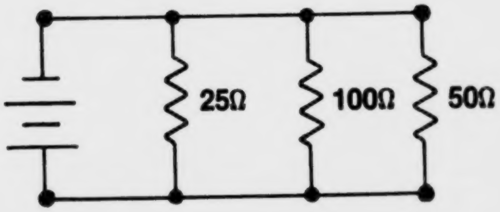
Directions: Apply the appropriate formula to find total resistance in the following problems. Show calculations in the space provided above each answer.

A.



Answer ______________

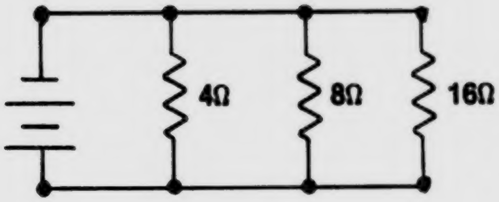
B.



Answer ______________

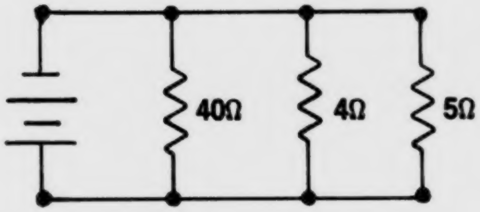
Assignment Sheet 10

C.



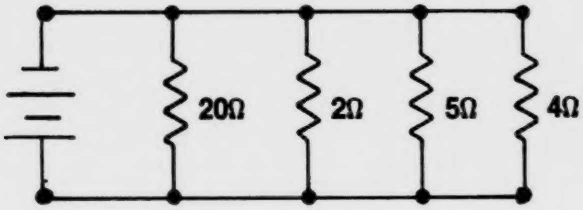
Answer ____________________

D.



Answer ____________________

E.



Answer ____________________

DC Circuits
Unit 9

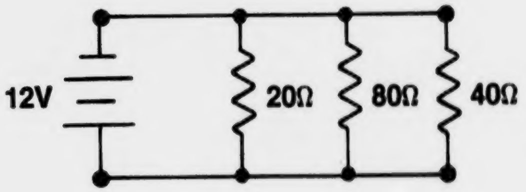
Assignment Sheet 11—Solve Problems for Unknown Current in Parallel Circuits

Name ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
Computed all problems and showed work	______
Labeled answers with correct unit of measurement	______
Computed a minimum of four of the five answers correctly per Assignment Sheet 11 answers	______

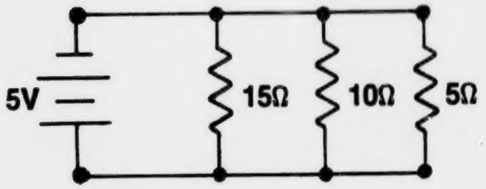
Directions: Apply the appropriate formula from Ohm's law to find current in the following problems. Show calculations in the space provided above each answer.

A.



Answer ____________________

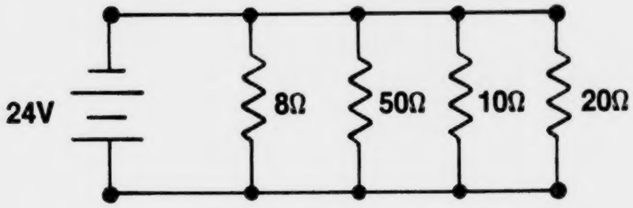
B.



Answer ____________________

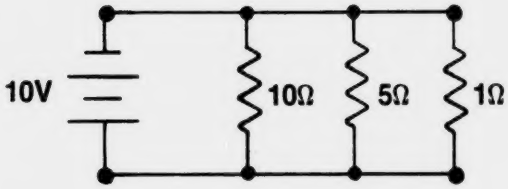
Assignment Sheet 11

C.


24V
8Ω
50Ω
10Ω
20Ω

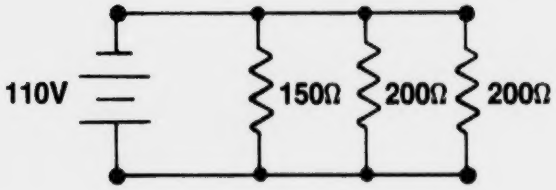
Answer ____________________

D.


10V
10Ω
5Ω
1Ω

Answer ____________________

E.


110V
150Ω
200Ω
200Ω

Answer ____________________

DC Circuits
Unit 9

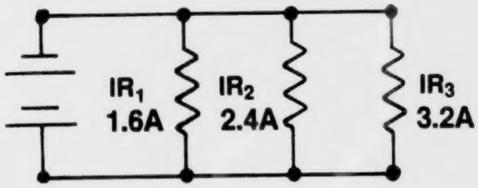
Assignment Sheet 12—Apply Kirchoff's Current Law to Parallel Circuits

Name ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
Computed all problems and showed work	______
Labeled answers with correct unit of measurement	______
Computed a minimum of four of the five answers correctly per Assignment Sheet 12 answers	______

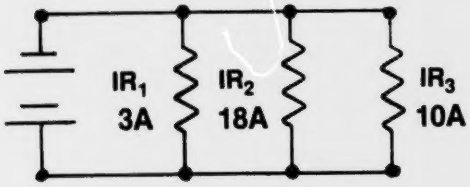
Directions: Using Kirchoff's current law, find the total current in the following problems. Show calculations in the space provided above each answer.

A.



Answer ________________

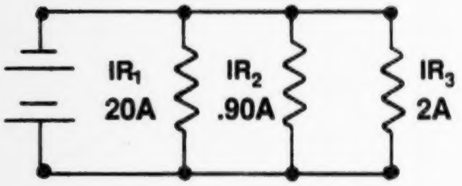
B.



Answer ________________

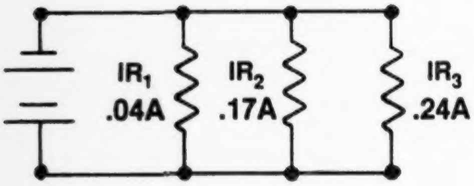
Assignment Sheet 12

C.


IR_1
20A
IR_2
.90A
IR_3
2A

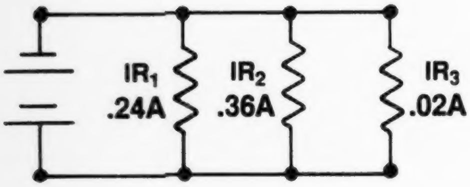
Answer ____________________

D.


IR_1
.04A
IR_2
.17A
IR_3
.24A

Answer ____________________

E.


IR_1
.24A
IR_2
.36A
IR_3
.02A

Answer ____________________

DC Circuits
Unit 9

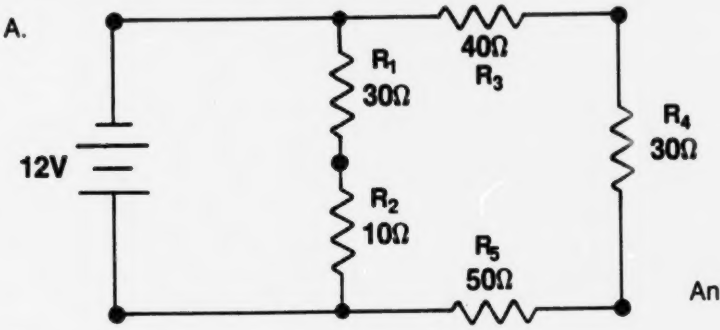
Assignment Sheet 13—Solve Problems for Unknown Resistance in Series-Parallel Circuits

Name ______________________ Overall Rating __________

Evaluation criteria	Rating
Computed all problems and showed work	______
Labeled answers with correct unit of measurement	______
Computed a minimum of two of the three answers correctly per Assignment Sheet 13 answers	______

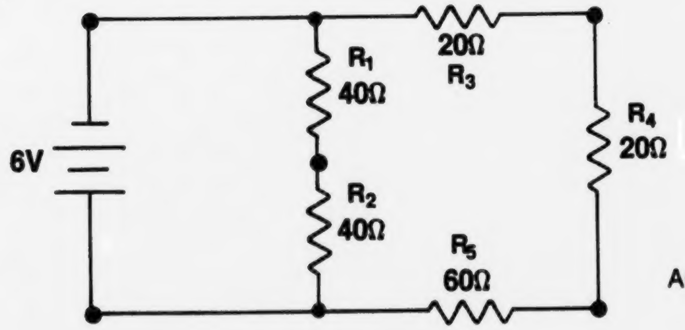
Directions: Apply the appropriate formula to find total resistance in the following problems. Show calculations in the space provided above each answer.

A.


12V
R1
30Ω
R2
10Ω
40Ω
R3
R4
30Ω
R5
50Ω

Answer ______________

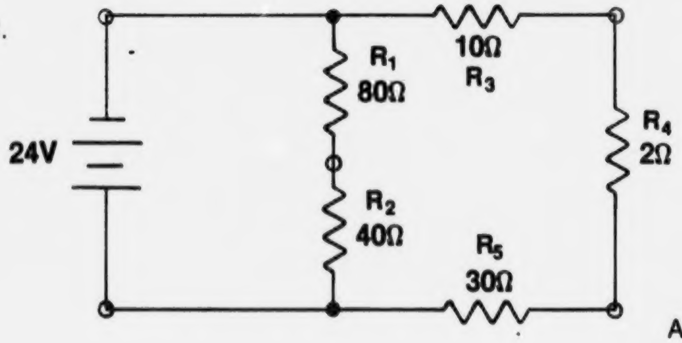
B.


6V
R1
40Ω
R2
40Ω
20Ω
R3
R4
20Ω
R5
60Ω

Answer ______________

Assignment Sheet 13

C.


24V
R₁
80Ω
10Ω
R₃
R₄
2Ω
R₂
40Ω
R₅
30Ω

Answer ____________________

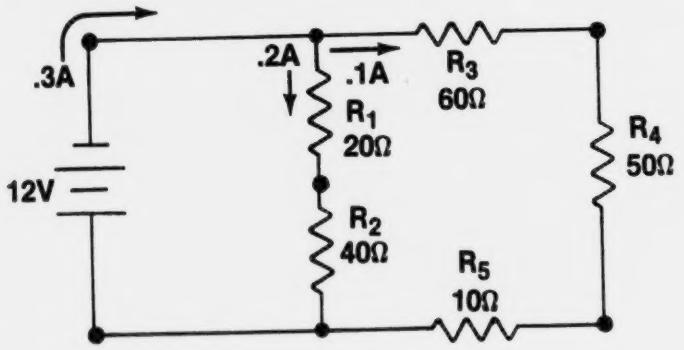
DC Circuits
Unit 9

Assignment Sheet 14—Solve Problems for Unknown Voltage in Series-Parallel Circuits

Name ______________________________ Overall Rating __________

Evaluation criteria	Rating
Computed all problems and showed work	_____
Labeled answers with correct unit of measurement	_____
Computed a minimum of four of the five answers correctly per Assignment Sheet 14 answers	_____

Directions: Apply the appropriate formula to find voltage in the following problems. Show calculations in the space provided below each answer.



A. Find voltage drop across R_1. __________

B. Find voltage drop across R_2. __________

C. Find voltage drop across R_3. __________

D. Find voltage drop across R_4. __________

E. Find voltage drop across R_5. __________

DC Circuits
Unit 9

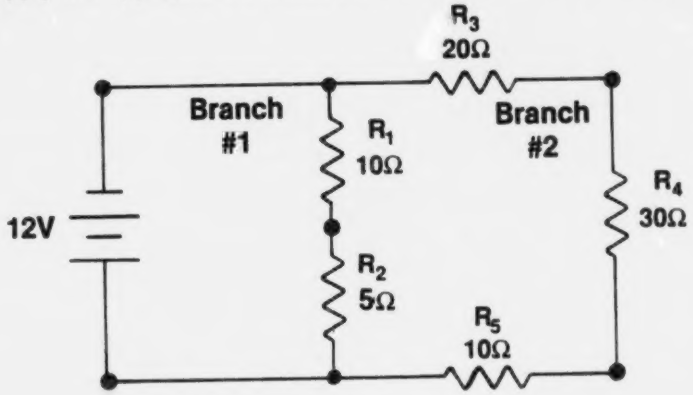
Assignment Sheet 15—Solve Problems for Unknown Current in Series-Parallel Circuits

Name ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
Computed all problems and showed work	______
Labeled answers with correct unit of measurement	______
Computed a minimum of four of the five answers correctly per Assignment Sheet 15 answers	______

Directions: Apply the appropriate formula to find current in the following problems. Show calculations.

A.



1. Total current ____________

2. Total current ____________

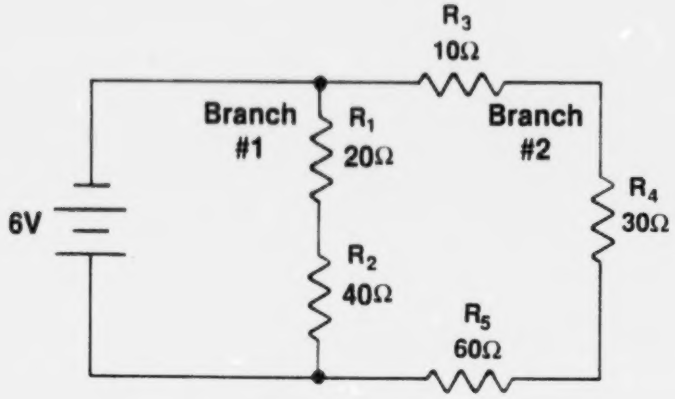
   Branch #1 ____________

3. Total current ____________

   Branch #2 ____________

Assignment Sheet 15

B.


R₃
10Ω
Branch
#1
R₁
20Ω
Branch
#2
R₄
30Ω
6V
R₂
40Ω
R₅
60Ω

1. Total current ____________

2. Total current ____________

Branch #1 ____________

3. Total current ____________

Branch #2 ____________

DC Circuits
Unit 9

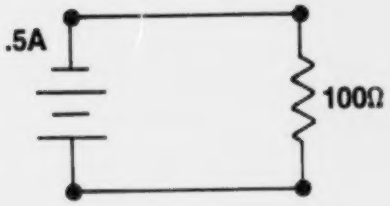
Assignment Sheet 16—Compute Power Using Ohm's Law

Name ________________________________ Overall Rating __________

Evaluation criteria	**Rating**
Computed all problems and showed work	_____
Labeled answers with correct unit of measurement	_____
Computed a minimum of four of the five answers correctly per Assignment Sheet 16 answers	_____

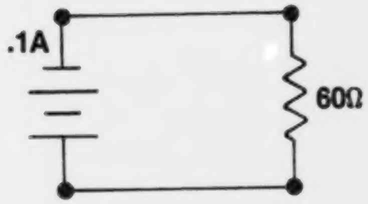
Directions: Apply Ohm's law to determine power in the following problems. Show calculations in the space provided above each answer.

A.



Answer ____________________

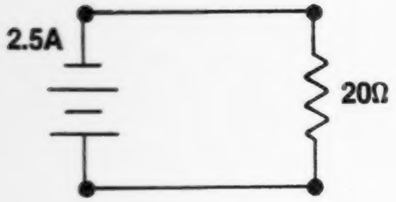
B.



Answer ____________________

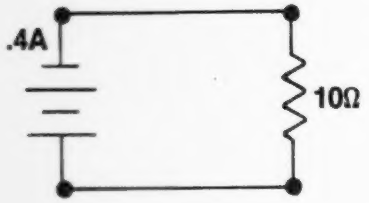
Assignment Sheet 16

C.



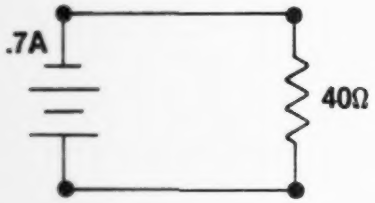
Answer ____________________

D.



Answer ____________________

E.



Answer ____________________

AC Circuits
Unit 10

Objective Sheet

Unit Objective

After completing this unit, the student should be able to construct and wire single, three-way, and four-way switches in a circuit. The student should demonstrate these competencies by completing the assignment and job sheets and scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to AC circuits with their correct definitions.
2. Select true statements about the principles of AC theory.
3. Complete statements related to the principles of induction.
4. Complete statements about inductance characteristics.
5. Select true statements about factors affecting inductors.
6. Select true statements about power characteristics in inductive circuits.
7. Complete statements about transformer characteristics.
8. List two classes of transformers.
9. Identify single-phase transformer connections.
10. Identify other transformer connections found in electrical trades.
11. Complete statements about power in three-phase circuits.
12. Select true statements about testing for polarity.
13. Complete statements about capacitance characteristics.
14. Select true statements about types, ratings, and common defects of capacitors.
15. Complete statements about capacitive Ac RC circuits.

Objective Sheet

16. Complete statements about inductive AC circuits.

17. Select true statements about power characteristics in AC circuits.

18. List three basic switching circuits used in electricity.

19. Solve power factor problems. (Assignment Sheet 1)

20. Solve RC and RL circuit problems. (Assignment Sheet 2)

21. Draw a diagram of a single-pole switch on a light. (Assignment Sheet 3)

22. Draw a diagram of two three-way switches on a light. (Assignment Sheet 4)

23. Draw a diagram of two three-way switches and a four-way switch on a light. (Assignment Sheet 5)

24. Wire a single-pole switch controlling a single lighting outlet with the supply line entering the switch box. (Job Sheet 1)

25. Wire a single-pole switch controlling a single lighting outlet with the supply line entering the lighting outlet box. (Job Sheet 2)

26. Wire a three-way switching situation with the supply line entering a single lighting outlet. (Job Sheet 3)

27. Wire a four-way switching situation with the supply line entering the lighting outlet box. (Job Sheet 4)

AC Circuits
Unit 10

Suggested Activities

Instructional Plan

Preparation

1. Read the unit carefully and plan for instruction. Study the specific objectives to determine the order in which you will present them.

2. Review Teaching Suggestions section that follows. Plan for classroom activities.

3. Plan your presentation to take advantage of student learning styles and to accommodate special needs students.

4. Make transparencies from the transparency masters included with this unit. The masters appear in the teacher edition only and are intended to be used with the following objectives:

   TM 1—Induced Current (Objective 3)
   TM 2—Induction (Objective 4)
   TM 3—Power in RL Circuits (Objective 5)
   TM 4—Classes of Transformers (Objective 8)
   TM 5—Impedance Relationships in an RC Circuit (Objective 13)
   TM 6—Electric Field Effect on Dielectrics (Objective 15)
   TM 7—Capacitor Construction (Objective 15)
   TM 8—Plate Area (Objective 15)
   TM 9—Plate Distance (Objective 15)
   TM 10—Effect of the Dielectric (Objective 15)
   TM 11—AC Switching Circuits (Objective 18)

5. Obtain films, videotapes, and other resources to supplement instruction of this unit. See ordering information in the Suggested Supplemental Resources section that follows.

6. Develop teaching plan. Adjust for different learning styles.

7. Make copies of Unit Evaluation Form.

Delivery and Application

8. Provide students with unit of instruction.

9. Discuss unit and specific objectives.

Suggested Activities

10. Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic skills when applicable.

11. Discuss the assignment sheets. Review criteria for evaluation of these activities.

12. Discuss the job sheets. Review criteria for evaluation of these activities.

Evaluation

13. Discuss the use of the Unit Evaluation Form with students. Discuss the rating scale that will be used for student evaluation.

14. Make copies of the written test. Add or modify test items as needed.

15. Give written test.

16. Compile assignment and job sheet ratings and written test scores on the Unit Evaluation Form. Include any additional assignments.

17. Reteach and retest as required.

Teaching Suggestions

Note: Skill areas appearing in boldface type in the Teaching Suggestions refer to the academic and workplace skills identified by the American Society for Training and Development (ASTD) and the U.S. Department of Labor. These have been adapted by MAVCC.

1. Have students view an AC waveform on an oscilloscope. Skill area: **Observing scientific application**

2. Take field trip to a house under construction, and view basic switching devices. Skill areas: **Listening, applying scientific principles**

3. Invite a representative from a local supply house to give a demonstration on switching. Skill area: **Listening**

4. Show students how to solve RC and RL circuit problems. Discuss calculations for Assignment Sheet 2 in class. Skill area: **Math**

Suggested Activities

Resources Used in Developing This Unit

1. Adams, James E. and Gorden Rockmaker. *Industrial Electricity Principles and Practices*, Third Edition. New York: McGraw-Hill Book Company, 1985.
2. *Basic Electricity Review*. Rockville, MD: NUS Training Corporation, a Halliburton Company, 1985.
3. Earley, Mark W., John M. Caloggero, and Richard H. Murray. *National Electrical Code 1993*. Quincy, MA: National Fire Protection Association, 1992.
4. Vorderstrasse, Ron. *General Electronics Technician*. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1986.

Suggested Supplemental Resources

Videotape — *Alternating Current*, VHS, 9 minutes. International Film Bureau Incorporated, 332 S. Michigan Avenue, Chicago, IL 60604-4382. Phone (800) 432-2241.

Book — Crost, Terrell, ed. *American Electrician's Handbook*, 11th ed. New York: McGraw-Hill, 1987.

Instructions for Evaluating Student Performance

Assignment Sheets—Be sure the student understands the criteria on which the evaluation is based. Assign a point value to each criterion and convert the total points to a percentage for grading.

Job Sheets—Be sure the student understands the criteria on which the evaluation is based. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in either the teacher edition or student manual. Then observe the student performing the procedure. Rate both process and product.

> Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily achieved the step(s) for each checkpoint area. If the student is unable to correctly complete the procedure, have the student review the materials and try again.
>
> Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria which have been provided as part of the job sheet. Complete the rating by assigning a point value to each criterion and by converting the point total to a percentage for grading. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Suggested Activities

Sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) which best fits your program needs.

Option A

4 - Skilled—Can perform job with no additional training.
3 - Moderately skilled—Has performed job during training program; limited additional training may be required.
2 - Limited skill—Has performed job during training program; additional training is required to develop skill.
1 - Unskilled—Is familiar with process, but is unable to perform job.

Option B

Yes—Can perform job with no additional training.

No—Is unable to perform job satisfactorily.

AC Circuits
Unit 10

Answers to Assignment Sheets

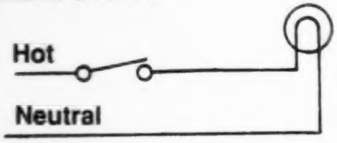
Assignment Sheet 1

A. 0.70 or 70%
B. 0.76 or 76%
C. 0.83 or 83%
D. 0.83 or 83%
E. 0.85 or 85%
F. 0.67 or 67%
G. 0.96 or 96%
H. 0.88 or 88%

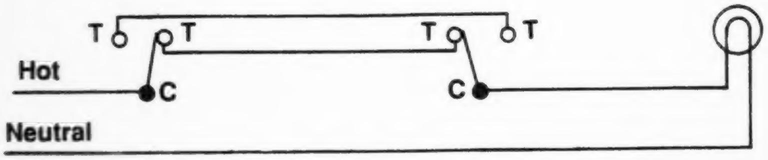
Assignment Sheet 2

A. 8.85 mΩ
B. $X_C = 13.2\Omega$; $I = 15.75A$
C. 131.88Ω
D. $X_L = 188.4\Omega$; $I = 0.53A$
E. $X_L = 226.08\Omega$; $Z = 2{,}211\Omega$

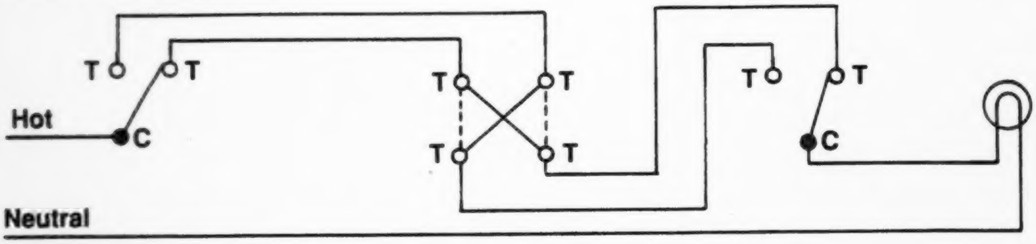
Assignment Sheet 3


Hot
Neutral

Assignment Sheet 4


T
T
T
T
Hot
C
C
Neutral

Assignment Sheet 5


T
T
Hot
C
T
T
T
T
T
T
C
Neutral

AC Circuits
Unit 10

Answers to Written Test

1. a. 11
   b. 9
   c. 2
   d. 6
   e. 3
   f. 10
   g. 5
   h. 7
   i. 12
   j. 4
   k. 8
   l. 1

2. a, c, f

3. a. Magnetic
   b. Electromagnetic
   c. (1) Strength
      (2) Speed
      (3) Angle
      (4) Length
   d. Oppose

4. a. Inductance
   b. Current flow
   c. L
   d. Henry
   e. Current
   f. H

5. a, b

6. a, b, c

7. a. Induction
   b. Different, voltages
   c. Metal core
   d. Step-up
   e. Step-down
   f. Autotransformers

8. a. Single-phase
   b. Three-phase

9. a. Parallel primary, parallel secondary
   b. Series primary, parallel secondary
   c. Series primary, series secondary
   d. Parallel primary, series secondary

Answers to Written Test

10. a. Delta-wye
    b. Delta-delta
    c. Delta
    d. Wye

11. a. Delta
    b. Wye

12. a, b

13. a. Capacitance
    b. Capacitor
    c. Dielectric
    d. (1) Area
       (2) Spacing
       (3) Dielectric
    e. Farad
    f. Farad

14. a, b, c, d, e

15. a. Flowing
    b. Dielectric
    c. Voltage
    d. Plate
    e. 90
    f. Leads
    g. Reactance

16. a. Opposition
    b. Expands
    c. Less
    d. 180
    e. Reactance
    f. Impedance
    g. RL

17. b, c

18. a. Single-pole switch
    b. Three-way switch
    c. Four-way switch

AC Circuits
Unit 10

Written Test

Name ____________________________ Score ______________

1. Match terms related to AC circuits with their correct definitions. Write the correct numbers in the blanks.

_____a. The shape of a wave as a function of time, distance, and amplitude

_____b. One power source

_____c. Transformer with a single winding

_____d. A resistance to current flow

_____e. Termination points where conductors are joined together

_____f. The power that a device is actually using

_____g. Amount of inductance into a conductor when the current changes at the rate of 1 ampere per second

_____h. Where voltage enters a transformer

_____i. Conductors coiled around a metal core in a transformer or motor

_____j. Insulating materials capable of accumulating an electrical charge

_____k. Where voltage leaves a transformer

_____l. Term used to describe the power that "appears" to be consumed in an RC circuit when the power formula VA = IE is applied to the circuit

1. Apparent power
2. Autotransformer
3. Connections
4. Dielectric materials
5. Henry
6. Opposition
7. Primary
8. Secondary
9. Single phase
10. True power
11. Waveform
12. Windings

Written Test

2. Select true statements about the principles of AC theory. Write an "X" in the blank before each true statement.

______a. AC current flows in two directions; it flows in one direction, stops, and then flows in the opposite direction.

______b. There are two basic types of waveforms: square wave and sawtooth wave.

______c. Sine waves are measured peak-to-peak in AC voltage or amperes.

______d. Peak-to-peak current and voltages occur three times in a cycle: one in the positive direction, one in neutral, and one in the negative direction.

______e. The rms (root-mean-square) or effective value of the sine wave is .007 times peak value.

______f. Electromotive force (emf) causes current to flow through a device; this is referred to in sine waves as V.

3. Complete the following statements related to the principles of induction. Write in the blanks the word(s) that best completes each statement.

a. __________________ induction occurs when a magnet is placed in close proximity to a ferromagnetic material causing the material to also become magnetized.

b. __________________ induction is the action that causes electrons to flow in a conductor when the conductor cuts the lines of force in a magnetic field.

c. The amount of current induced into the conductor is determined by four factors (Faraday's law):

(1) __________________ of the magnetic field

(2) __________________ of the conductor with respect to the field

(3) __________________ at which the conductor cuts the field

(4) __________________ of the conductor in the field

d. Lenz's law states that the direction of the induced current must be such that its own magnetic field will __________________ the action that produced the induced current.

630

Written Test

4. Complete the following statements about inductance characteristics. Write in the blanks the word(s) or letter that best completes each statement.

   a. ___________________ is the physical property of a circuit or device that indicates an ability to oppose a change in current.

   b. Inductance may be defined as the ability to induce an EMF into a conductor when there is a change in ___________________ ___________________.

   c. The symbol for inductance is the letter ___________________.

   d. The unit of measurement for inductance is the ___________________.

   e. A Henry is the amount of inductance that induces an EMF of 1 volt into a conductor when the ___________________ changes at the rate of 1 ampere per second.

   f. The Henry is expressed symbolically with the letter ___________________.

5. Select true statements about factors affecting inductors. Write an "X" in the blank before each true statement.

   ______a. An inductor is a physical device consisting of a coil of wire usually wound on a core.

   ______b. The inductance of a coil varies as the square of the number of turns.

   ______c. Inductance of a coil may be decreased dramatically by winding the coil on a core of material that has a high permeability.

   ______d. Inductance varies inversely with the winding of the coil.

6. Select true statements about power characteristics in inductive circuits. Write an "X" in the blank before each true statement.

   ______a. No power is dissipated in a pure inductance.

   ______b. Power dissipation in an RL circuit occurs in the resistance within the circuit.

   ______c. Since power is dissipated only in the resistance, it may be calculated using the standard power formulas.

Written Test

7. Complete the following statements about transformer characteristics. Write in the blanks the word(s) that best completes each statement.

   a. The transformer is one use of the ________________ process.

   b. Different electrical devices require ________________ operating ________________. Transformers change these voltages to meet a specific need.

   c. Transformers have three basic parts: a primary conductor, a secondary conductor, and a ________________.

   d. When the windings on the primary side are decreased and the windings on the secondary side are increased, this is called a ________________ transformer.

   e. When the windings on the primary side are increased and the windings on the secondary side decreased, this is called a ________________ transformer.

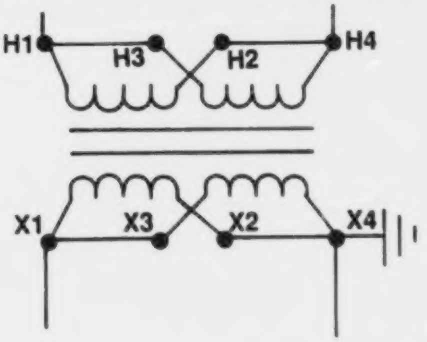
   f. ________________ have a single winding that acts as a primary and secondary.

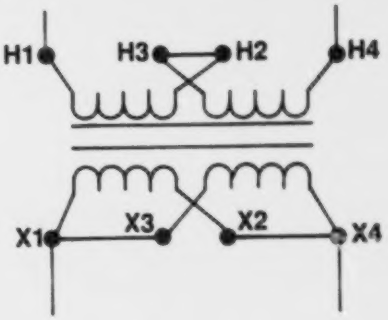
8. List the two classes of transformers.

   a. ____

   b. ____

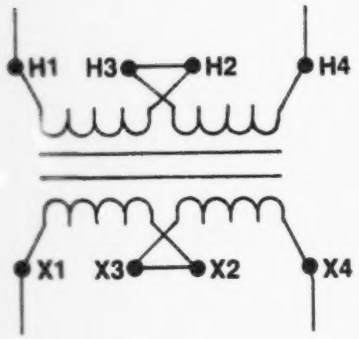
9. Identify single-phase transformer connections. Write the correct names in the blanks.

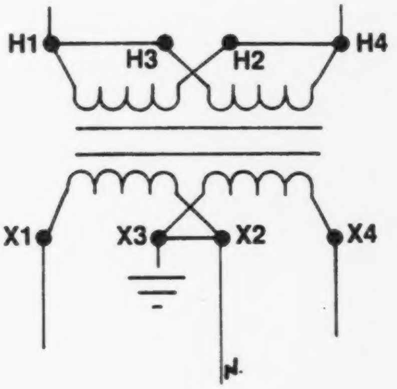




a. ____________________ b. ____________________

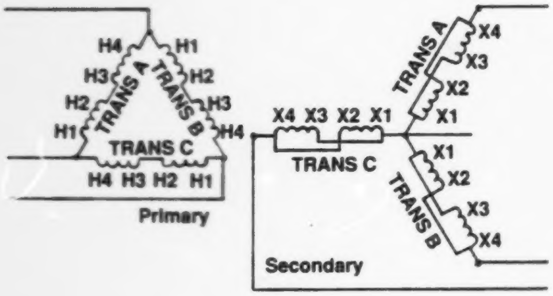
Written Test

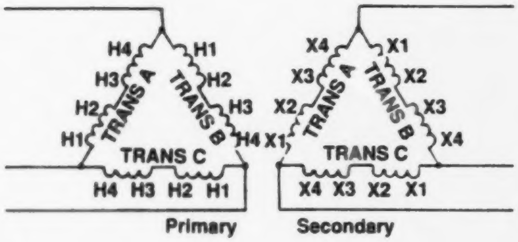

H1
H3
H2
H4
X1
X3
X2
X4


H1
H3
H2
H4
X1
X3
X2
X4
N.

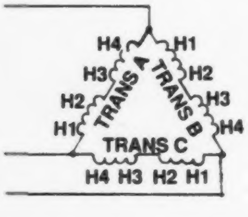
c. ______________________ d. ______________________

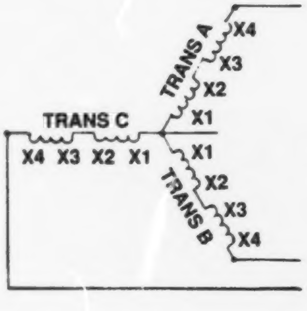
10. Identify other transformer connections found in electrical trades. Write the correct names in the blanks.


H4
H1
H3
H2
H2
H3
H1
H4
TRANS A
TRANS B
TRANS C
H4 H3 H2 H1
Primary
X4 X3 X2 X1
TRANS C
TRANS A
X4
X3
X2
X1
X1
X2
X3
X4
TRANS B
Secondary


H4
H1
H3
H2
H2
H3
H1
H4
TRANS A
TRANS B
TRANS C
H4 H3 H2 H1
Primary
X4
X1
X3
X2
X2
X3
X1
X4
TRANS A
TRANS B
TRANS C
X4 X3 X2 X1
Secondary

a. ______________________ b. ______________________


H4
H1
H3
H2
H2
H3
H1
H4
TRANS A
TRANS B
TRANS C
H4 H3 H2 H1


TRANS A
X4
X3
X2
X1
TRANS C
X4 X3 X2 X1
X1
X2
X3
X4
TRANS B

c. ______________________ d. ______________________

Written Test

11. Complete the following statements about power in three-phase circuits. Circle the word that best completes each statement.

    a. (Wye, Delta) — Voltage across each load member is full-line voltage; amperage in each member is $\sqrt{3}$ × line amps or 1.732 × amps

    b. (Delta, Wye) — Amperage in each member is full-line amperage; voltage across each member is $\sqrt{3}$ × line volts or 1.732 × volts.

12. Select true statements about testing for polarity. Write an "X" in the blank before each true statement.

    ______a. When testing a transformer for polarity, there are two kinds of windings: additives and subtractives.

    ______b. When testing a transformer for polarity, connect one test lead to the high voltage side and the other test lead to the low voltage tap directly under the high voltage tap.

    ______c. If the meter reads the incoming voltage, it is a subtractive.

    ______d. If the meter reads less than the incoming voltage, it is an additive.

    ______e. When finding the taps for an additive transformer, the taps are usually opposite each other.

    ______f. When finding the taps for a subtractive transformer the taps are usually directly under each other.

13. Complete the following statements about capacitance characteristics. Write in the blanks the word(s) that best completes each statement.

    a. The property of a circuit or device that enables it to store electrical energy with an electrostatic field is called ________________.

    b. A device that is made to have a specific value of capacitance is called a ________________.

    c. A capacitor is a device constructed of two metal plates separated by a ________________.

    d. Capacitance of a capacitor is determined by three factors:

        (1) The ________________ of the metal plates.

        (2) The ________________ between the plates.

        (3) The type or nature of the ________________.

Written Test

e. The unit of capacitance is the __________________.

f. One __________________ is the amount of capacitance that will store a charge of one coulomb when 1 volt of EMF is applied.

14. Select true statements about types, ratings, and common defects of capacitors. Write an "X" in the blank before each true statement.

______a. There are two basic types of capacitors: fixed value capacitors and variable capacitors.

______b. Capacitors are classified by the type of dielectric used, such as mica, ceramic, paper, and mylar.

______c. Capacitors may be an electrolytic type.

______d. Capacitors are rated according to value of capacitance.

______e. Defects in capacitors are related to four common failures.

15. Complete statements about capacitive AC circuits. Write the correct words in the blanks.

__________________a. When voltage is applied to a capacitor in an AC circuit, it will appear that electrons are (*flowing, static*) in the circuit.

__________________b. Electrons will not travel through the (*voltage field, dielectric*) of a capacitor.

__________________c. As the applied (*voltage, capacitance*) increases and decreases in amplitude, the capacitor will charge and discharge.

__________________d. The movement of electrons from one (*frequency, plate*) to another represents current flow.

__________________e. Current and voltage do not flow in phase in a capacitive circuit: when the current is at its maximum, the voltage is at 0, thus the relationship is (*180, 90*) degrees out of phase.

__________________f. The current (*leads, lags*) the applied voltage in a capacitive circuit.

Written Test

_________________g. After a capacitor is initially charged by an AC voltage, the voltage stored on the plates opposes any change in the applied voltage. This opposition to change in voltage is known as capacitive (*inductance, reactance*).

16. Complete statements about inductive AC circuits. Write the correct words in the blanks.

_________________a. In AC circuits, inductors offer (*opposition, assistance*) to current flow.

_________________b. As an AC voltage is applied to an inductor, or an inductive circuit, a magnetic field (*contracts, expands*) and collapses around the inductor.

_________________c. This magnetic field induces a voltage in the windings of the inductor. This is called counter-electromotive force (CEMF). CEMF is always (*more, less*) than the applied EMF.

_________________d. CEMF is an effective means of controlling current flow because it is (*90, 180*) degrees out of phase of the applied voltage and opposes the applied voltage.

_________________e. Oppostion to current flow in inductive AC circuits is known as inductive (*reactance, impedance*).

_________________f. The combination of both resistance and reactance is called (*inductance, impedance*).

_________________g. The most common inductive circuit consists of an inductor connected in series with a resistor. This is called an (*RC, RL*) circuit.

17. Select true statements about power characteristics in AC circuits. Write an "X" in the blank before each true statement.

______a. In an AC circuit, voltage and current are always in phase.

______b. The power or product of voltage and current must be multiplied by a power factor to determine the true power.

______c. By using a meter one can determine the true power in a circuit.

Written Test

18. List three basic switching circuits used in electricity.

    a. ____________________

    b. ____________________

    c. ____________________

*Permission to duplicate this test is granted.

AC Circuits
Unit 10

Unit Evaluation Form

Student Name ______________________ Unit Rating ________

Assignment Sheet 1—Solve Power Factor Problems Rating ______

Comments: ______________________

Assignment Sheet 2—Solve RC and RL Circuit Problems Rating ______

Comments: ______________________

Assignment Sheet 3—Draw a Diagram of a Single-Pole Switch on a Light Rating ______

Comments: ______________________

Assignment Sheet 4—Draw a Diagram of Two Three-Way Switches on a Light Rating ______

Comments: ______________________

Assignment Sheet 5—Draw a Diagram of Two Three-Way Switches and a Four-Way Switch on a Light Rating ______

Comments: ______________________

Job Sheet 1—Wire a Single-Pole Switch Controlling a Single Lighting Outlet with the Supply Line Entering the Switch Box Rating ______

Comments: ______________________

Job Sheet 2—Wire a Single-Pole Switch Controlling a Single Lighting Outlet with the Supply Line Entering the Lighting Outlet Box Rating ______

Comments: ______________________

638

Unit Evaluation Form

Job Sheet 3—Wire a Three-Way Switching Situation with the Supply Line Entering a Single Lighting Outlet   Rating ______

Comments: ____

____

Job Sheet 4—Wire a Four-Way Switching Situation with the Supply Line Entering the Lighting Outlet Box   Rating ______

Comments: ____

____

Written Test Scores

Pretest ______   Posttest ______   Other ______

Other ____

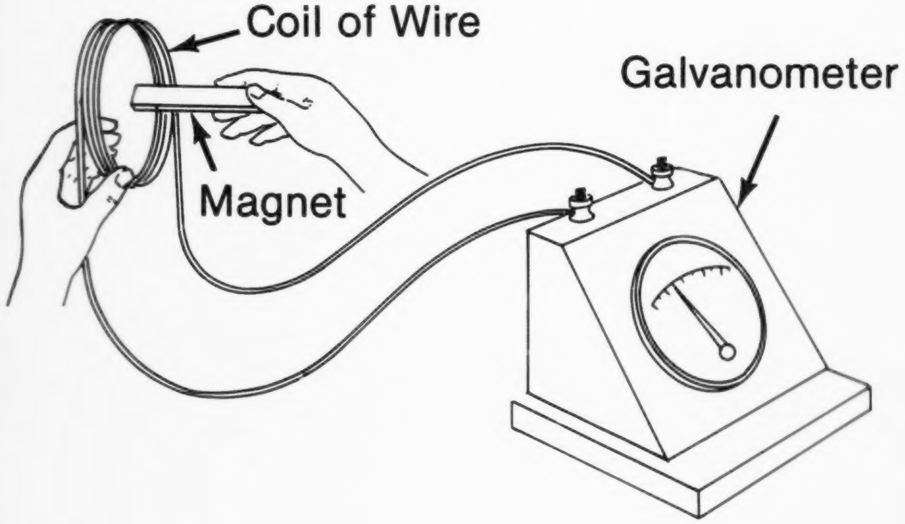
____

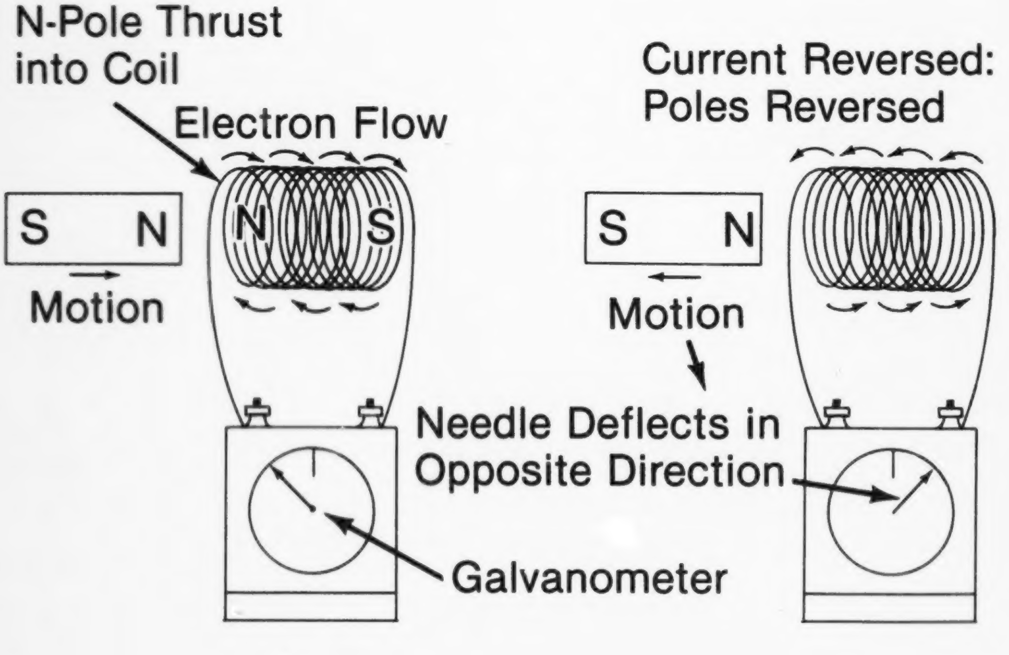
Teacher Signature ____________________   Date ____________

Student Signature ____________________   Date ____________

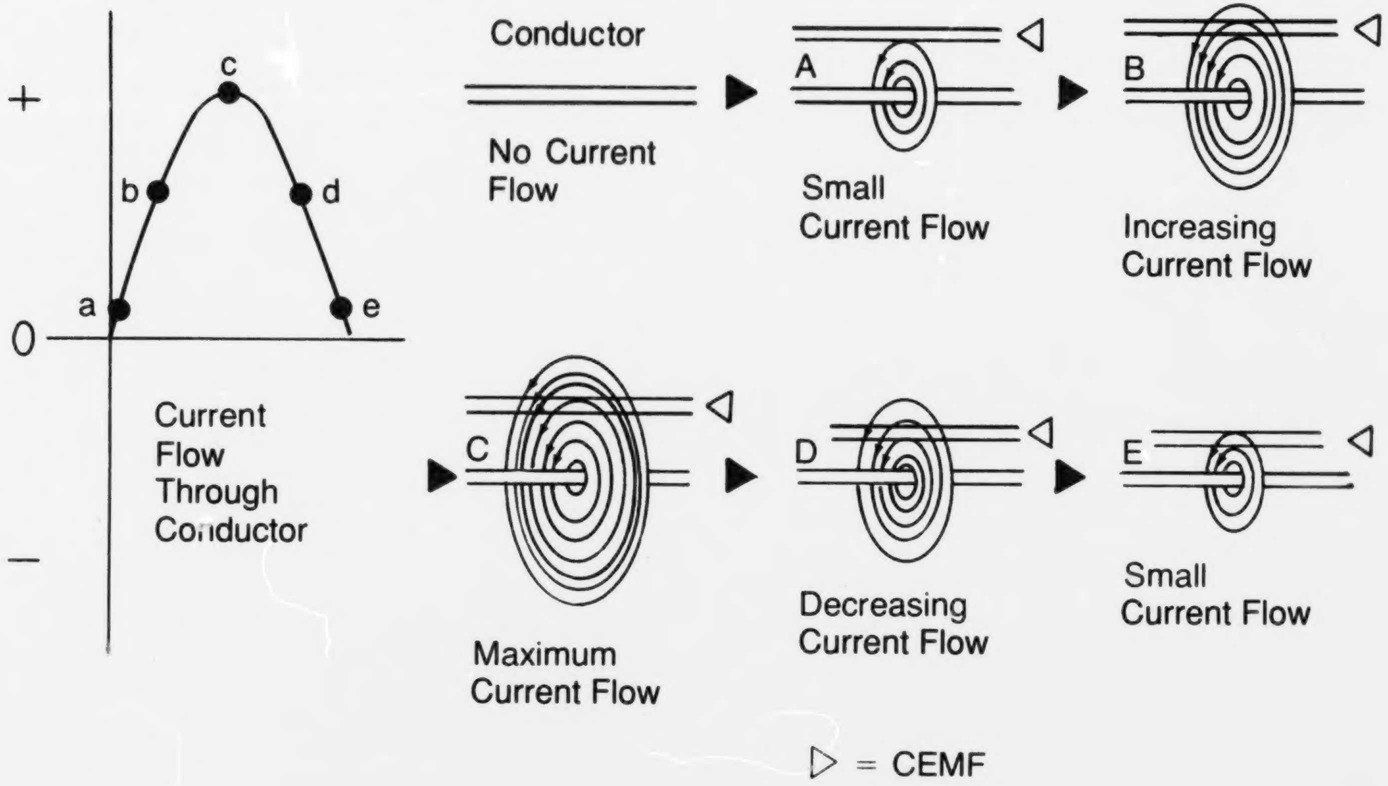
***Permission to duplicate this form is granted.**

Induced Current


Coil of Wire
Galvanometer
Magnet


N-Pole Thrust into Coil
Electron Flow
S
N
N
S
Motion
Current Reversed: Poles Reversed
S
N
Motion
Needle Deflects in Opposite Direction
Galvanometer

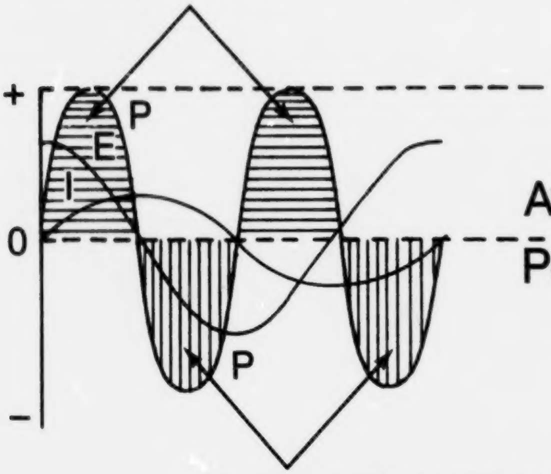
Induction


+
0
−
a
b
c
d
e
Current Flow Through Conductor
Conductor
No Current Flow
A
Small Current Flow
B
Increasing Current Flow
C
Maximum Current Flow
D
Decreasing Current Flow
E
Small Current Flow
▷ = CEMF

Relationship of magnetic field around a wire to current flowing through the wire

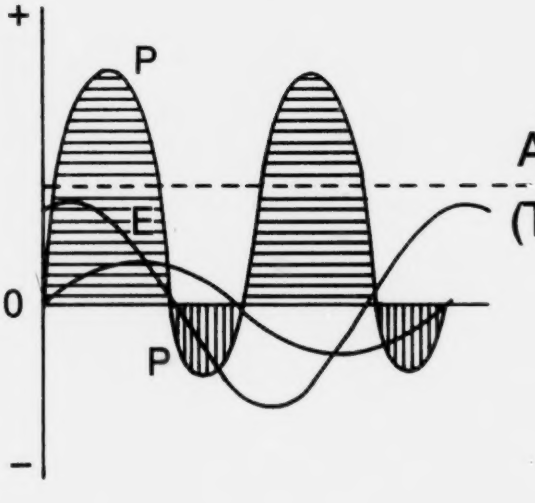
Power in RL Circuits

Power Consumed by the Inductor



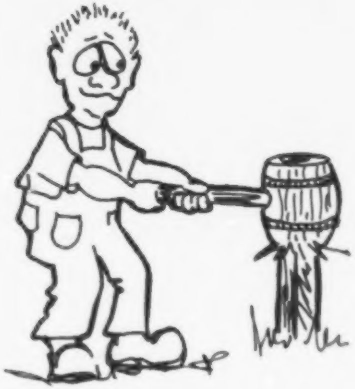
Average Power - Zero

Power Returned to the Circuit by the Inductor

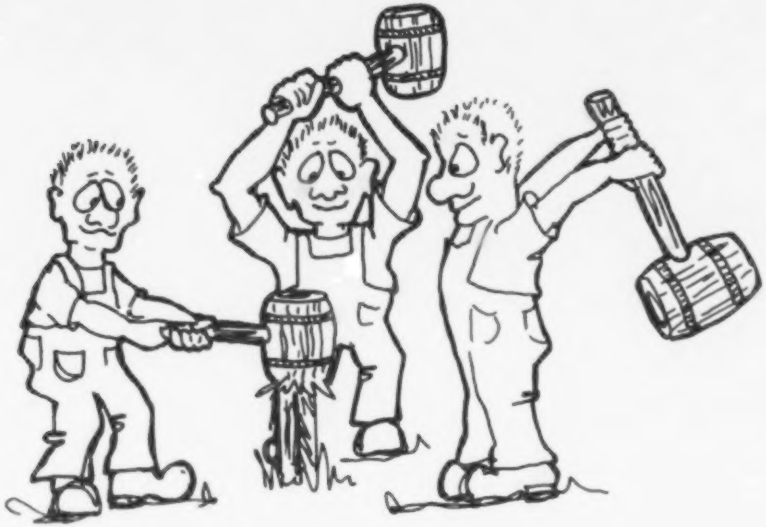


Average (True) Power

Classes of Transformers

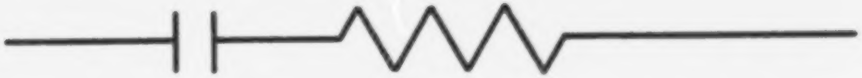


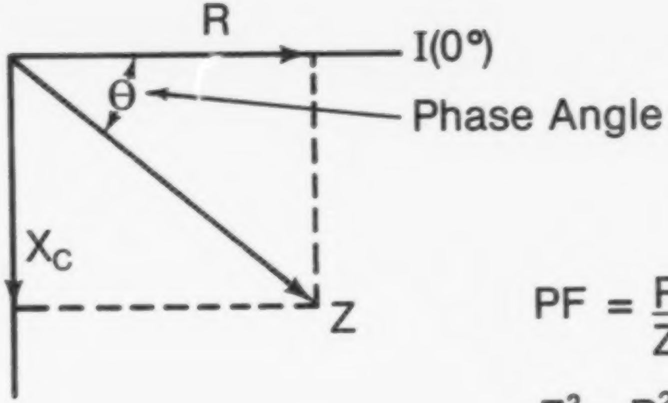
Single Phase



Three Phase

Impedance Relationships in an RC Circuit

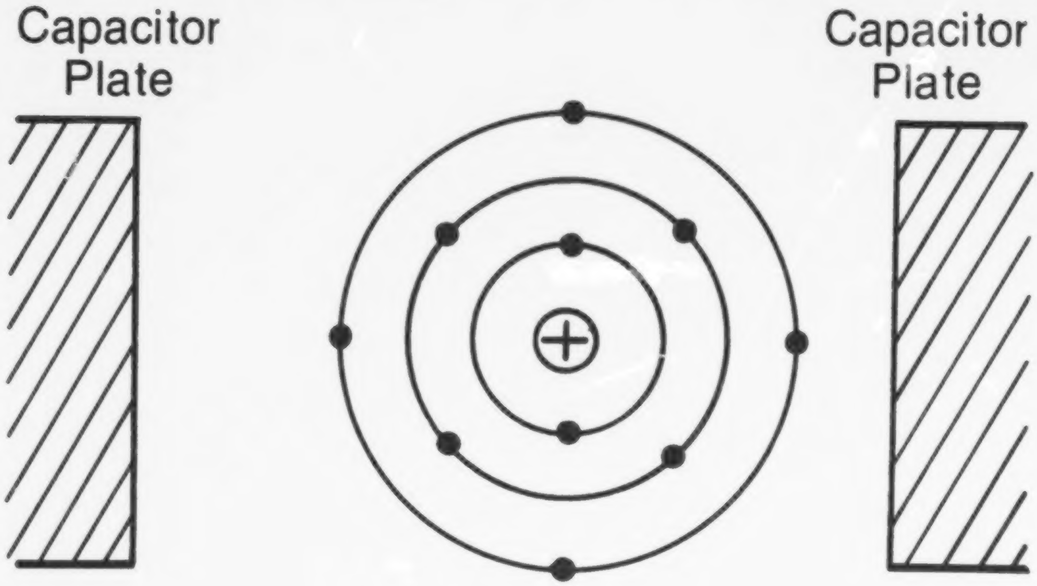



R
I(0°)
θ
Phase Angle
X_C
Z

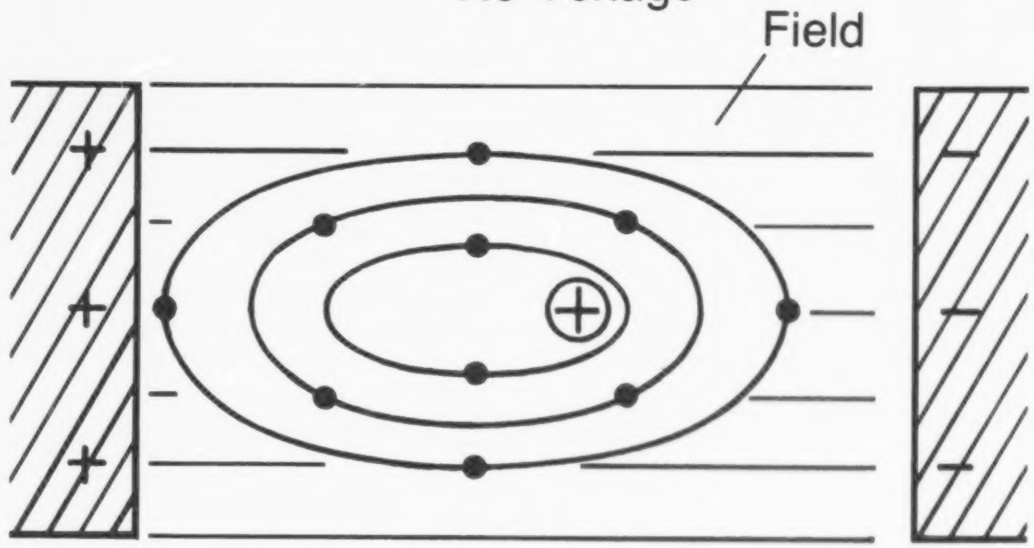
$$PF = \frac{R}{Z}$$

$$Z^2 = R^2 + X_C^2$$

Electric Field Effect on Dielectrics


Capacitor Plate
Capacitor Plate

No Voltage



Voltage Applied

Capacitor Construction

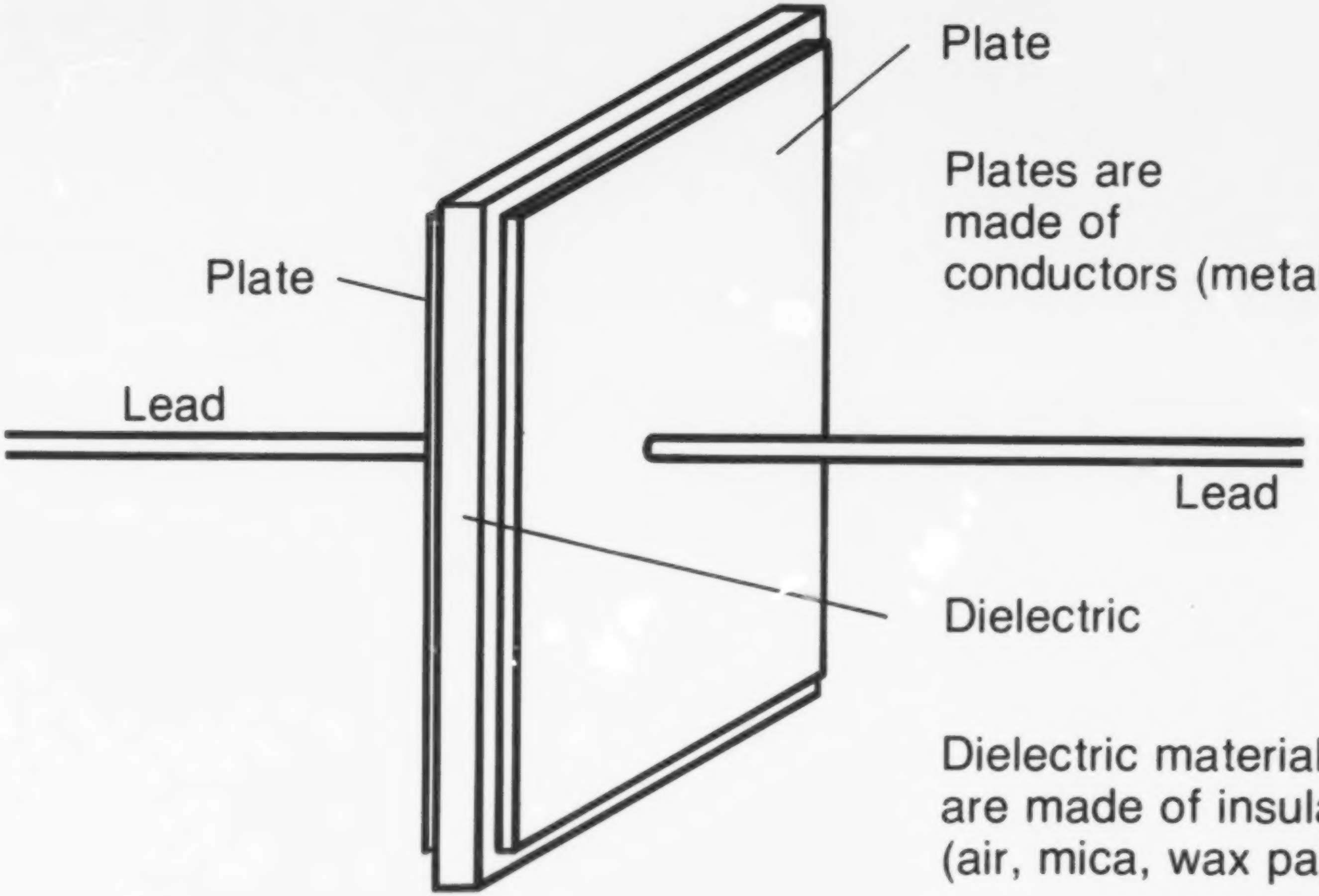
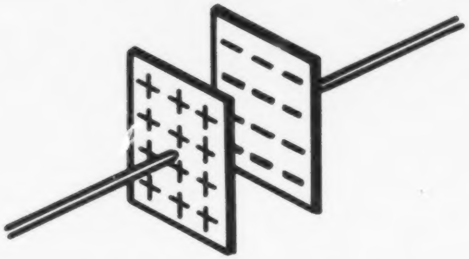


Plate
Plate
Lead
Lead
Dielectric

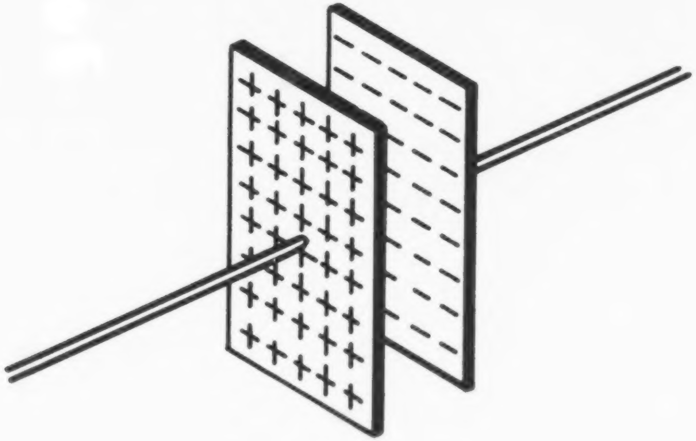
Plates are
made of
conductors (metals).

Dielectric materials
are made of insulators
(air, mica, wax paper).

Plate Area



Larger plates hold more electrons.

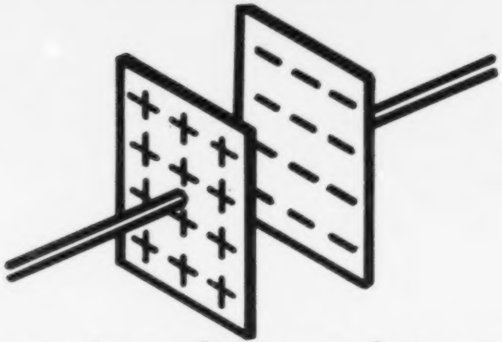


Increased plate area increases capacitance.

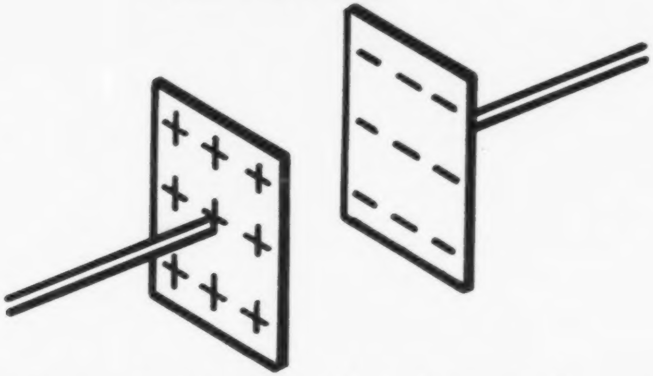
Basic Wiring, Unit 10
Teacher Page 35

TM 8

Plate Distance



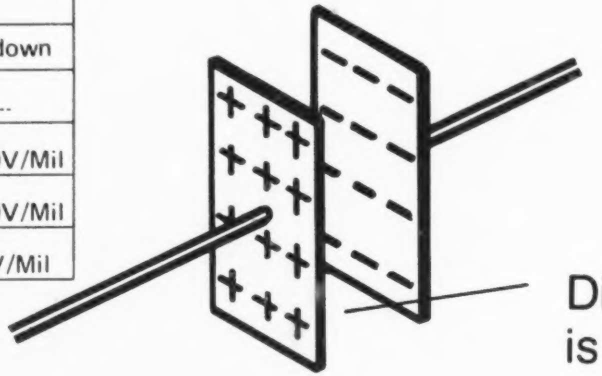
The distance between two charges determines their effect on one another.



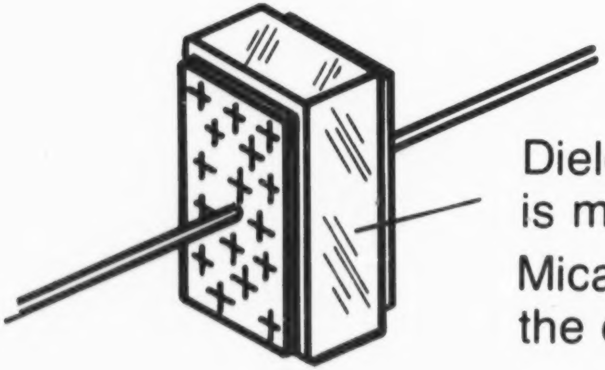
Increasing the distance between the plates decreases capacitance.

Effect of the Dielectric

Typical Dielectrics		
Type	Constant	Breakdown
Air	1.0	-----
Mica	5.4	5000V/Mil
Teflon	2.1	1500V/Mil
Paper	3.0	200V/Mil



Dielectrical material is air.

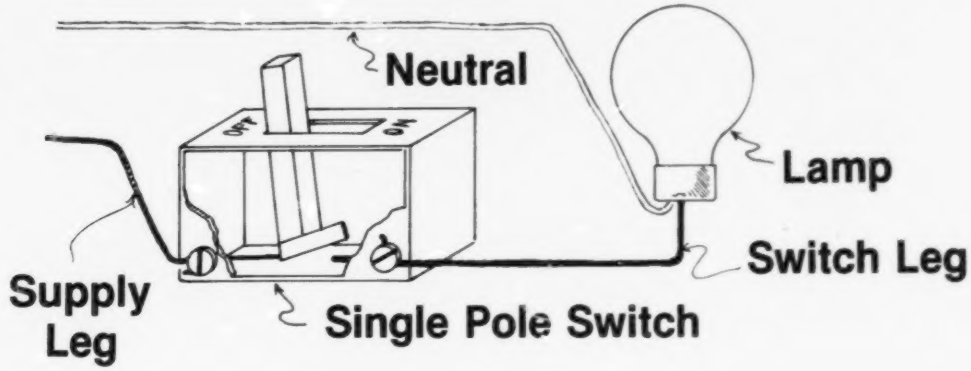


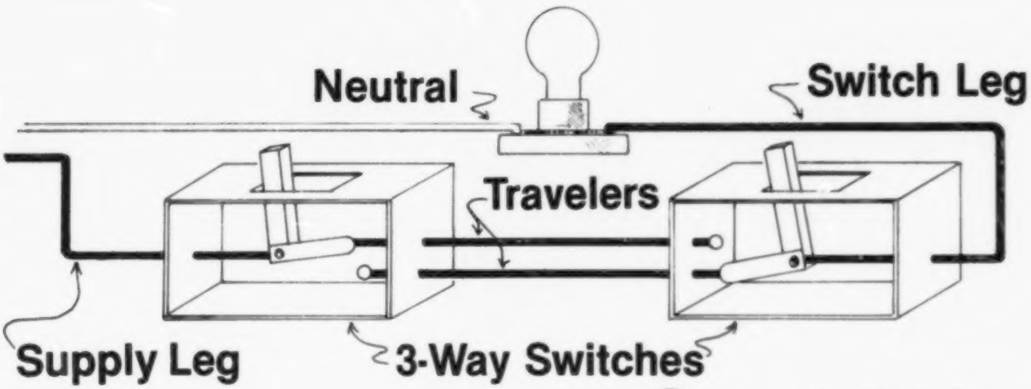
Dielectrical material is mica.

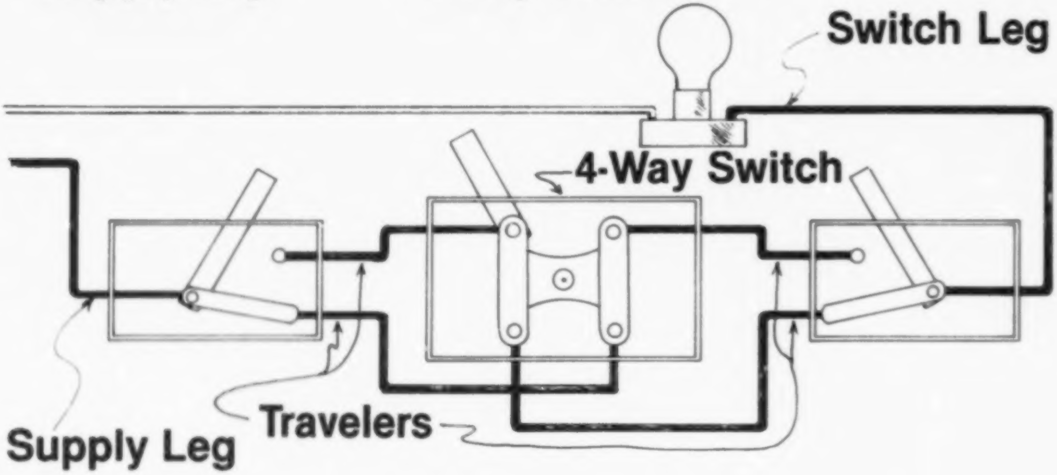
Mica dielectric increases the capacitance.

Changing the dielectric material changes the capacitance.

AC Switching Circuits


Neutral
OFF
ON
Lamp
Switch Leg
Supply Leg
Single Pole Switch


Neutral
Switch Leg
Travelers
Supply Leg
3-Way Switches


Switch Leg
4-Way Switch
Travelers
Supply Leg

AC Circuits
Unit 10

Information Sheet

1. **Terms and definitions**

   a. **Apparent power** — Term used to describe the power that "appears" to be consumed in an RC circuit when the power formula VA = IE is applied to the circuit

   b. **Autotransformer** — Transformer with a single winding

   c. **Connections** — Termination points where conductors are joined together

   d. **Dielectric materials** — Insulating materials capable of accumulating an electrical charge

   e. **Henry** — Amount of inductance into a conductor when the current changes at the rate 1 ampere per second

   f. **Opposition** — Resistance to current flow

   g. **Primary** — Transformer winding that receives power from the source

   h. **Secondary** — Transformer winding that receives power from the primary winding

   i. **Single phase** — One AC power source

   j. **True power** — The power that a device is actually using

   k. **Waveform** — The shape of a wave as a function of time, distance, and amplitude

   l. **Windings** — Conductors coiled around a metal core in a transformer or motor

Information Sheet

2. **Principles of AC theory** (Figures 1-4)

   a. AC current flows in two directions; it flows in one direction, stops, and then flows in the opposite direction.

   b. There are three basic types of waveforms: sine wave, square wave, and sawtooth wave.

Figure 1—Sine Wave

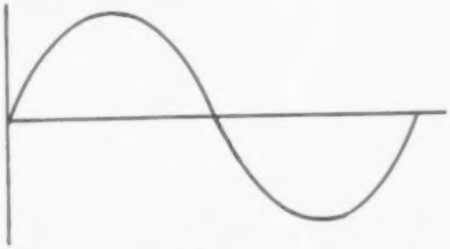


Figure 2—Square Wave

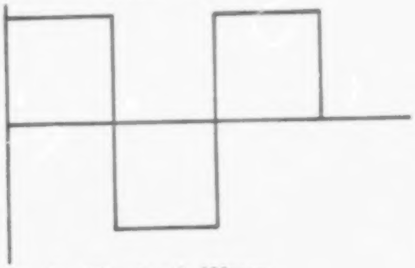
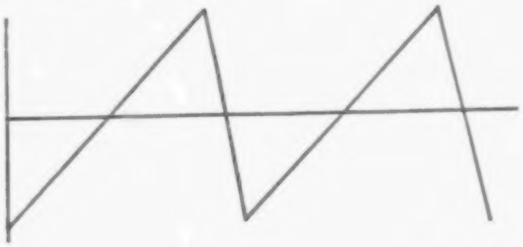


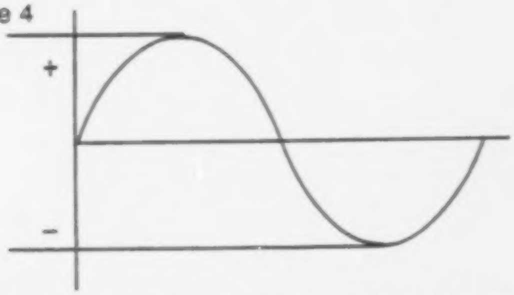
Figure 3—Sawtooth Wave



Information Sheet

c. Sine waves are measured peak-to-peak in AC voltage or amperes.

Figure 4



d. Peak-to-peak current and voltages occur twice in a cycle: one in the positive direction and one in the negative direction.

e. The rms (root-mean-square) or effective value of the sine wave is 0.707 times peak value.

f. Electromotive force (emf) causes current to flow through a device; this is referred to in sine waves as V.

3. **Principles of induction**

a. Magnetic induction occurs when a magnet is placed in close proximity to a ferromagnetic material causing the material to also become magnetized.

b. Electromagnetic induction is the action that causes electrons to flow in a conductor when the conductor cuts the lines of force in a magnetic field.

c. The amount of current induced into the conductor is determined by four factors (Faraday's law):

- **Strength** of the magnetic field
- **Speed** of the conductor with respect to the field
- **Angle** at which the conductor cuts the field
- **Length** of the conductor in the field

d. Lenz's law states that the direction of the induced current must be such that its own magnetic field will oppose the action that produced the induced current.

Information Sheet

4. **Characteristics of inductance**

   a. Inductance is the physical property of a circuit or device that indicates an ability to oppose a change in current.

   b. Inductance may be defined as the ability to induce an EMF into a conductor when there is a change in current flow.

   c. The symbol for inductance is the letter L.

   d. The unit of measurement for inductance is the Henry.

      - A Henry is the amount of inductance that induces an EMF of 1 volt into a conductor when the current changes at the rate of 1 ampere per second.

      - The Henry is expressed symbolically with the letter H.

      Note: The Henry is relatively large unit, therefore the millihenry (mH) and the microhenry (uH) are the units generally used in practice.

5. **Factors affecting inductors**

   a. An inductor is a physical device consisting of a coil of wire usually wound on a core.

      Note: An inductor may also be called a *coil* or *choke*.

   b. The inductance of a coil varies as the square of the number of turns.

   c. Inductance of a coil may be increased dramatically by winding the coil on a core of material that has a high permeability.

   d. Inductance varies inversely with the length of the coil.

6. **Power characteristics in an inductive circuit** (Figures 5 and 6)

   a. No power is dissipated in a pure inductance.

      Note: Scientists are unable to make totally pure inductors; therefore, all inductors have some resistance within the wire of which they are made.

   b. Power dissipation in an RL circuit occurs in the resistance within the circuit.

Information Sheet

c. Since power is dissipated only in the resistance, it may be calculated using the standard power formulas.

Examples: $P = EI$ $P = I^2R$ $P = \frac{E^2}{R}$

Figure 5

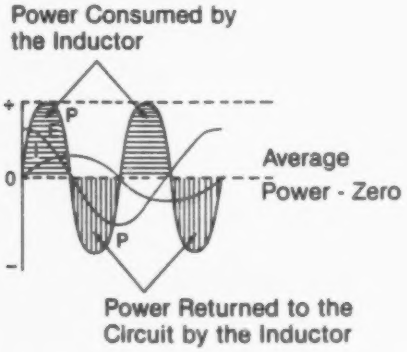
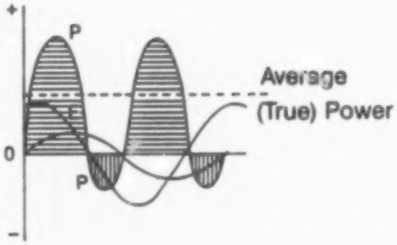


Figure 6



7. **Characteristics of a transformer** (Figures 7-10)

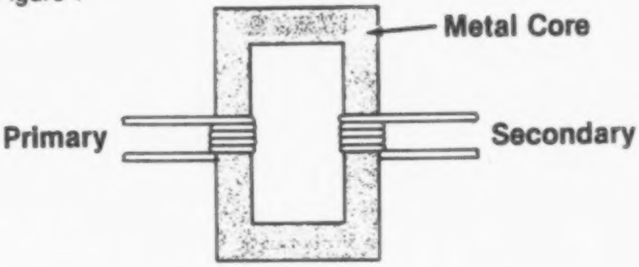
   a. The transformer is one use of the induction process.

   b. Different electrical devices require different operating voltages. Transformers change these voltages to meet a specific need.

Information Sheet

c. Transformers have three basic parts: a primary conductor, a secondary conductor, and a metal core.

Figure 7


Metal Core
Primary
Secondary

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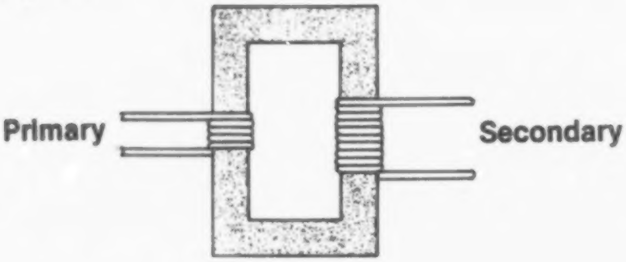
d. When the windings on the primary side are decreased and the windings on the secondary side are increased, this is called a step-in transformer.

Figure 8


Primary
Secondary

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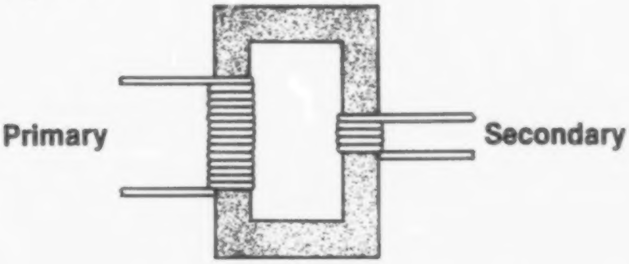
e. When the windings on the primary side are increased and the windings on the secondary side decreased, this is called a step-down transformer.

Figure 9


Primary
Secondary

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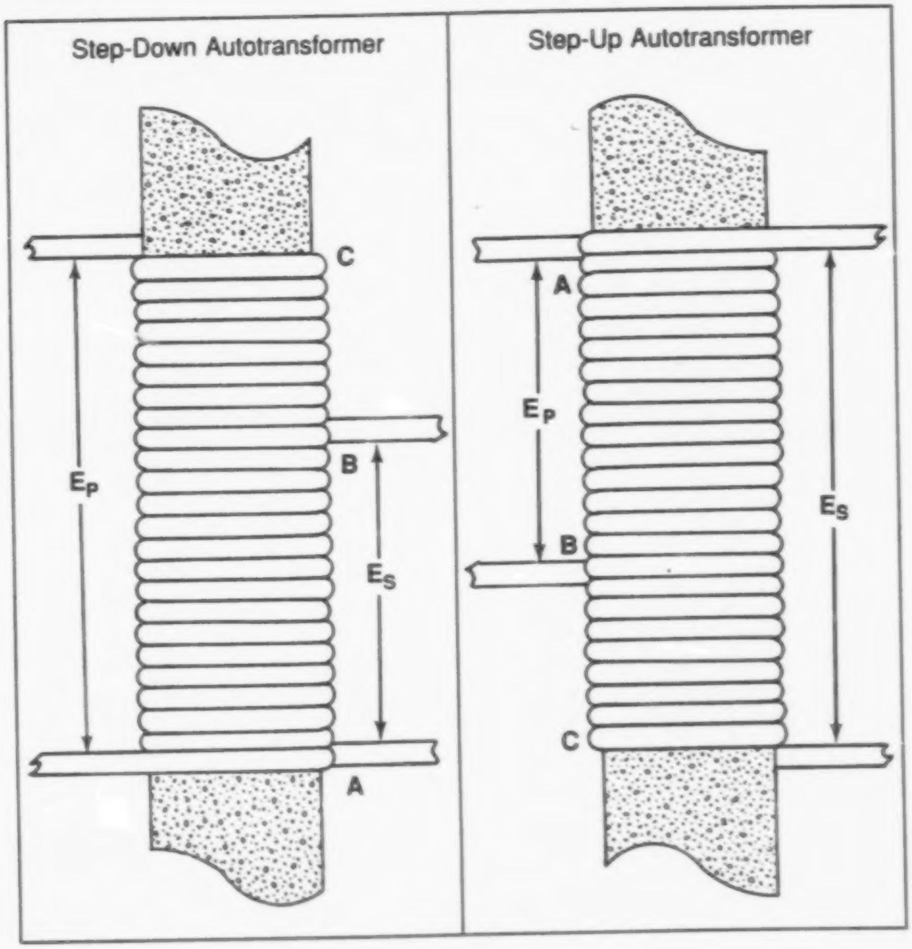
Information Sheet

f. Autotransformers have a single winding that acts as a primary and secondary.

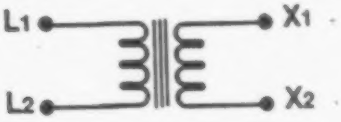
Figure 10


Step-Down Autotransformer
C
B
A
E_P
E_S
Step-Up Autotransformer
A
B
C
E_P
E_S

8. **Classes of transformers** (Figures 11 and 12)

a. Single-phase

Figure 11

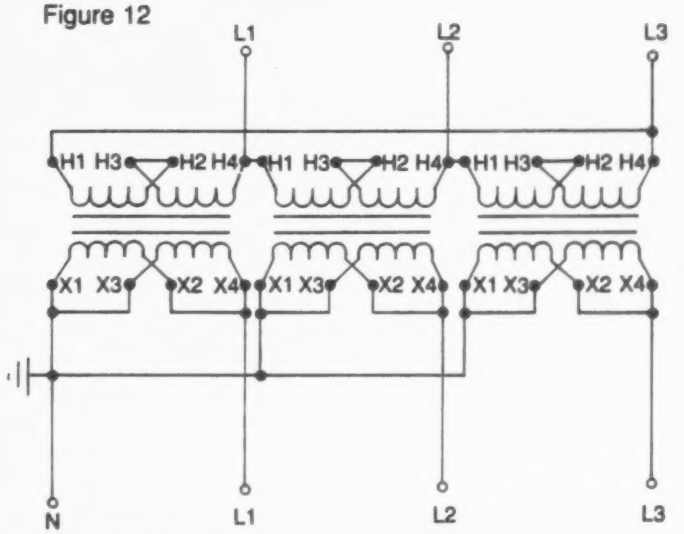


Information Sheet

b. Three-phase

Note: Three single-phase transformers can be used to make a three-phase transformer if they are of the same values.

Figure 12

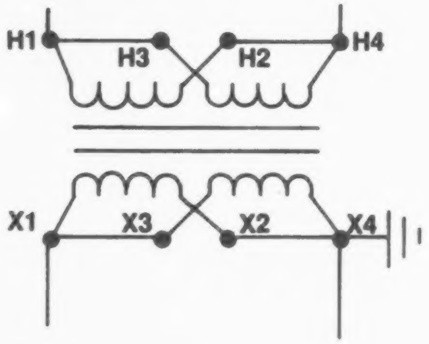

L1
L2
L3
H1 H3
H2 H4
H1 H3
H2 H4
H1 H3
H2 H4
X1 X3
X2 X4
X1 X3
X2 X4
X1 X3
X2 X4
N
L1
L2
L3

9. **Transformer connections on a single-phase system** (Figures 13-16)

Note: These are the four most common connections used on dual winding, single-phase transformers.

a. Parallel primary, parallel secondary (usually 240 volt to 120 volt)

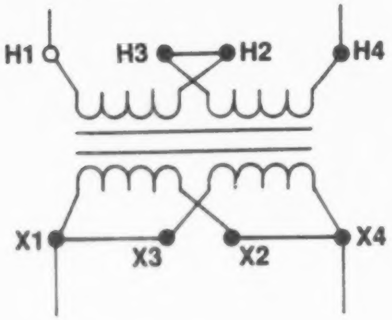
Figure 13


H1
H3
H2
H4
X1
X3
X2
X4

Information Sheet

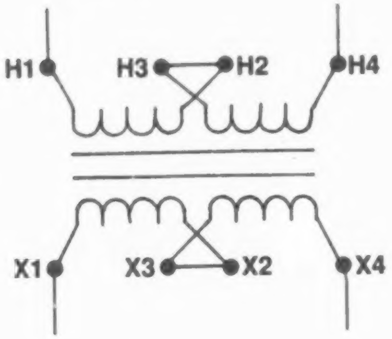
b. Series primary, parallel secondary (usually 480 volt to 120 volt)

Figure 14


H1
H3
H2
H4
X1
X3
X2
X4

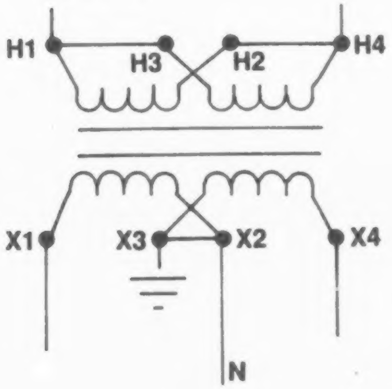
c. Series primary, series secondary (usually 480 volt to 240 volt)

Figure 15


H1
H3
H2
H4
X1
X3
X2
X4

d. Parallel primary, series secondary (usually 240 volt to 120 volt)

Figure 16


H1
H3
H2
H4
X1
X3
X2
X4
N

Information Sheet

10. **Other transformer connections found in electrical trades** (Figures 17-27)

   a. Delta

Figure 17

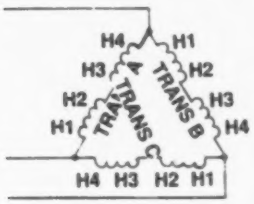
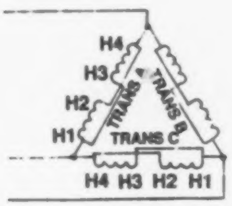

H4
H1
H3
H2
H2
H3
H1
H4
TRANS A
TRANS B
TRANS C
H4 H3 H2 H1

Figure 18


H4
H3
H2
H1
TRANS A
TRANS B
TRANS C
H4 H3 H2 H1

   b. Wye

Figure 19

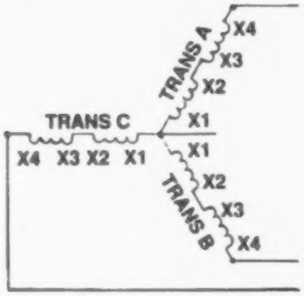
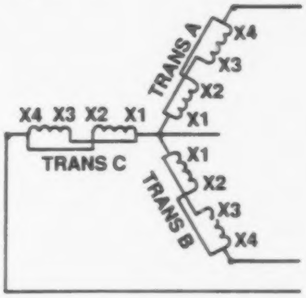

TRANS A
X4
X3
X2
X1
TRANS C
X4 X3 X2 X1
X1
X2
X3
X4
TRANS B

Figure 20


TRANS A
X4
X3
X2
X1
X4 X3 X2 X1
TRANS C
X1
X2
X3
X4
TRANS B

   c. Delta-wye

Figure 21

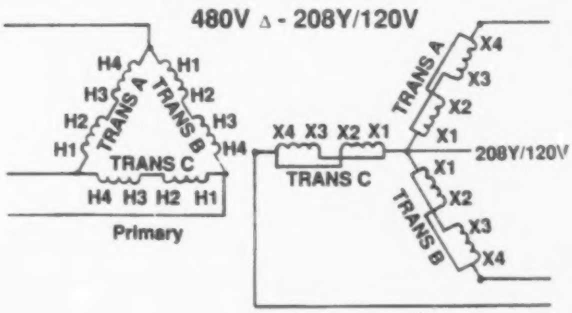
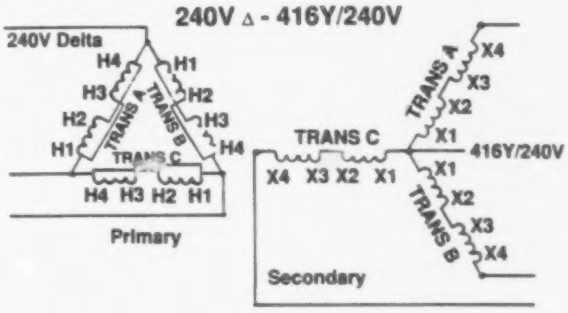
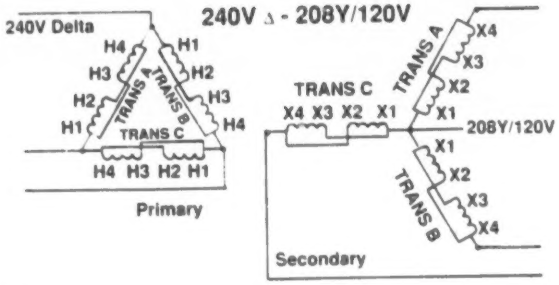

480V Δ - 208Y/120V
H4
H1
H3
H2
H2
H3
H1
H4
TRANS A
TRANS B
TRANS C
H4 H3 H2 H1
Primary
X4 X3 X2 X1
TRANS C
TRANS A
X4
X3
X2
X1
208Y/120V
X1
X2
X3
X4
TRANS B

Figure 22


240V Δ - 416Y/240V
240V Delta
H4
H1
H3
H2
H2
H3
H1
H4
TRANS A
TRANS B
TRANS C
H4 H3 H2 H1
Primary
TRANS C
X4 X3 X2 X1
TRANS A
X4
X3
X2
X1
416Y/240V
X1
X2
X3
X4
TRANS B
Secondary

Information Sheet

Figure 23


240V Δ - 208Y/120V
240V Delta
H1
H2
H3
H4
TRANS A
TRANS B
TRANS C
H4 H3 H2 H1
Primary
TRANS C
X4 X3 X2 X1
TRANS A
X4
X3
X2
X1
208Y/120V
TRANS B
Secondary

d. Delta-delta

Figure 24

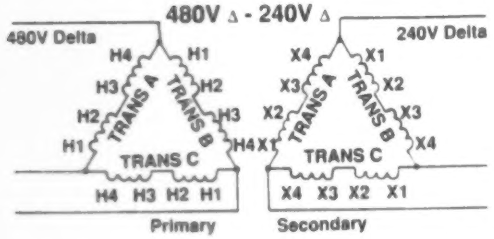

480V Δ - 240V Δ
480V Delta
240V Delta
H1
H2
H3
H4
X1
X2
X3
X4
TRANS A
TRANS B
TRANS C
H4 H3 H2 H1
X4 X3 X2 X1
Primary
Secondary

Figure 25

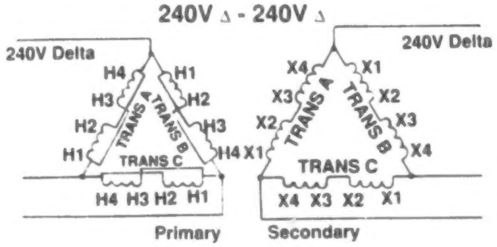

240V Δ - 240V Δ
240V Delta
240V Delta
H1
H2
H3
H4
X1
X2
X3
X4
TRANS A
TRANS B
TRANS C
H4 H3 H2 H1
X4 X3 X2 X1
Primary
Secondary

Figure 26

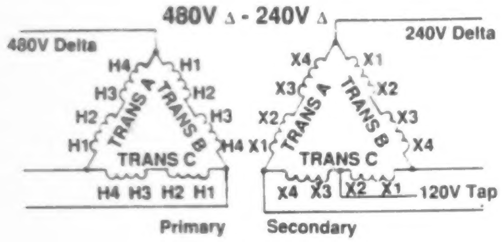
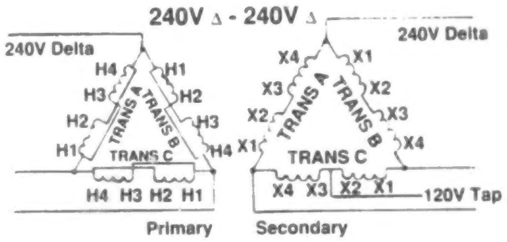

480V Δ - 240V Δ
480V Delta
240V Delta
H1
H2
H3
H4
X1
X2
X3
X4
TRANS A
TRANS B
TRANS C
H4 H3 H2 H1
X4 X3 X2 X1
120V Tap
Primary
Secondary

Figure 27


240V Δ - 240V Δ
240V Delta
240V Delta
H1
H2
H3
H4
X1
X2
X3
X4
TRANS A
TRANS B
TRANS C
H4 H3 H2 H1
X4 X3 X2 X1
120V Tap
Primary
Secondary

11. Power in three-phase circuits

a. **Delta** — Voltage across each load member is full-line voltage; amperage in each member is $\sqrt{3} \times$ line amps or $1.732 \times$ amps.

b. **Wye** — Amperage in each member is full-line amperage; voltage across each member is $\sqrt{3} \times$ line volts or $1.732 \times$ volts.

Note: To find the power in delta or wye circuits, use the formula $P = I \times \sqrt{3} \times E$.

Information Sheet

Example: A three-phase circuit has 10 amperes measured on each line. The voltage is 480 volts. It is not known whether the circuit is delta or wye. What is the power of the circuit?

Solution: $P = I \times \sqrt{3} \times E$

$= 10 \times 1.732 \times 480$

$= 8{,}314$ VA

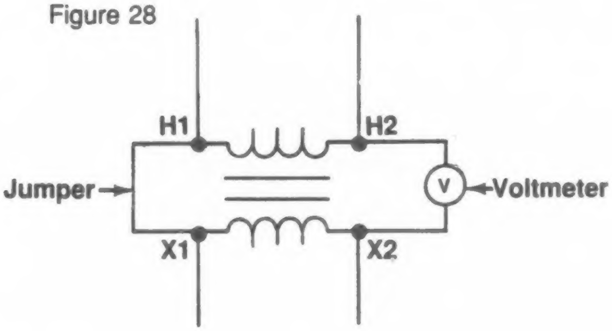
$= 8.3$ kVA

12. **Testing for polarity** (Figures 28 and 29)

a. When testing a transformer for polarity, there are two kinds of windings: additives and subtractives.

b. When testing a transformer for polarity, connect the primary to the secondary on one side and connect a meter between the primary and secondary on the other side. Apply the primary voltage. If the polarity is additive, the meter will read the primary voltage plus the secondary voltage. If the polarity is subtractive, the meter will read something less than the applied voltage.

Figure 28

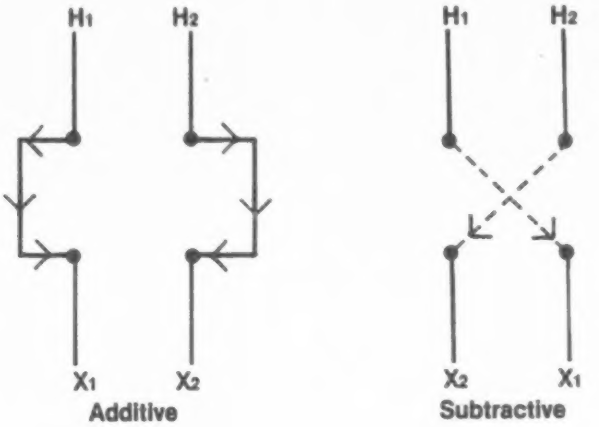


c. When finding the taps for an additive transformer, the taps are usually directly under each other.

Information Sheet

d. When finding the taps for a subtractive transformer, the taps are usually opposite each other.

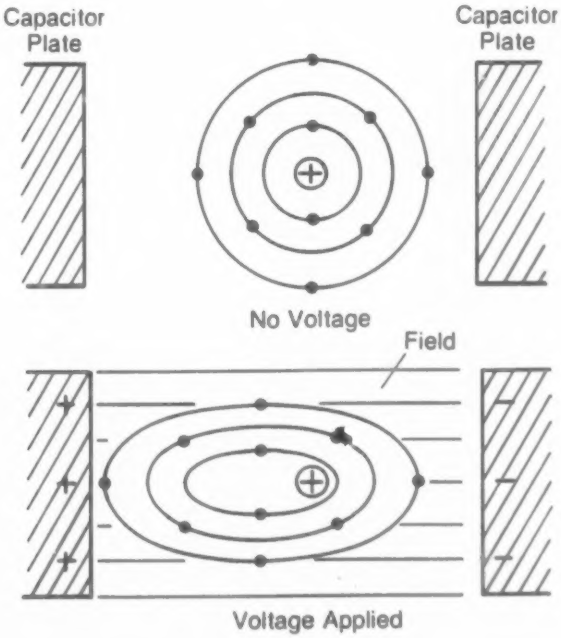
Figure 29


H_1
H_2
X_1
X_2
Additive
H_1
H_2
X_2
X_1
Subtractive

13. **Characteristics of capacitance** (Figure 30-34)

a. The property of a circuit or device that enables it to store electrical energy with an electrostatic field is called capacitance.

Figure 30


Capacitor Plate
Capacitor Plate
No Voltage
Field
Voltage Applied

Information Sheet

b. A device that is made to have a specific value of capacitance is called a capacitor.

- The number of electrons that a capacitor can store for a given applied voltage is a measure of its capacitance.
- A capacitor has the ability to store electrons and discharge them at a later time.

c. A capacitor is a device constructed of two metal plates separated by a dielectric.

Figure 31

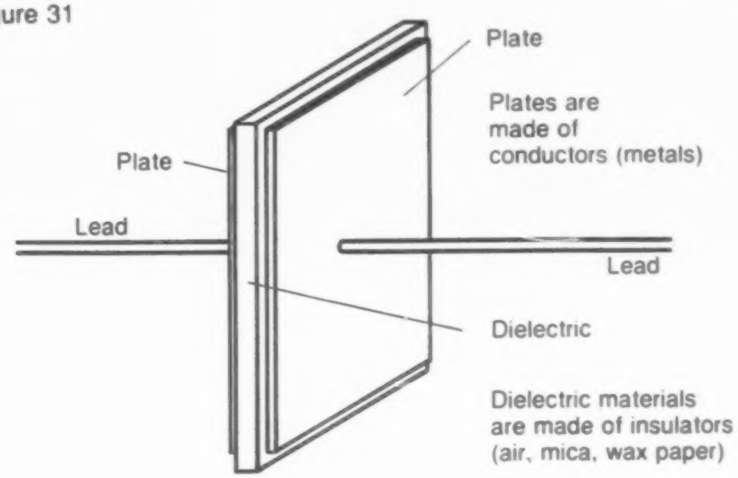
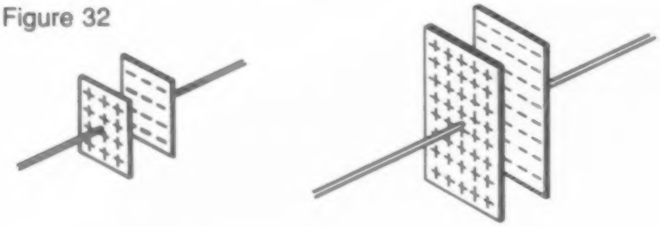


Plate
Plates are made of conductors (metals)
Plate
Lead
Lead
Dielectric
Dielectric materials are made of insulators (air, mica, wax paper)

d. Capacitance of a capacitor is determined by three factors:

- The **area** of the metal plates.

Figure 32

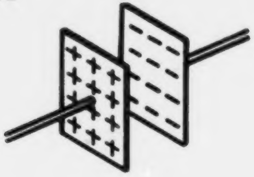


Information Sheet

- The **spacing** between the plates.

  Note: The distance between two charges determines their effect. Increasing the distance between the plates decreases capacitance.

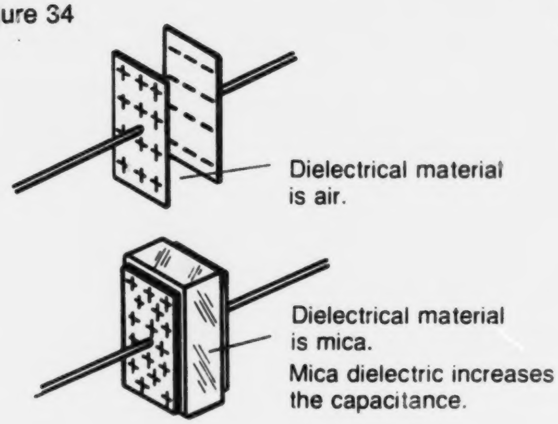
  Figure 33



- The **type** or **nature** of the dielectric.

  Note: Changing the dielectric material changes the capacitance.

  Figure 34


Dielectrical material
is air.
Dielectrical material
is mica.
Mica dielectric increases
the capacitance.

e. The unit of capacitance is the farad (F).

f. One farad is the amount of capacitance that will store a charge of 1 coulomb when 1 volt of EMF is applied.

Note: The farad is a very large unit and therefore is commonly expressed in terms of microfarads or picofarads.

g. Capacitance may be expressed in terms of charge and voltage by the formula $C = Q/E$ (C is the capacitance, Q is the quantity of electrical charge in coulombs, and E is the applied voltage).

Information Sheet

14. Types, ratings, and common defects of capacitors

a. Capacitors are classified according to a number of factors.

- There are two basic types: fixed-value capacitors and variable capacitors.
- Capacitors are classified by the type of dielectric used, such as mica, ceramic, paper, or mylar.
- Capacitors may be an electrolytic type.

  Note: Polarity must be observed.

b. Capacitors are rated according to value of capacitance.

c. Defects in capacitors are related to four common failures:

- Shorts occur when the dielectric is punctured or otherwise fails.
- A capacitor may open when one or both leads become disconnected from the plates.
- Excessive leakage may develop when a resistive path forms between the two plates (partial failure of dielectric).
- The capacitor may change in value due to a manufacturing defect or improper use (excessive temperature or applied voltage may cause a change in value).

15. Capacitive AC circuits

a. When voltage is applied to a capacitor in an AC circuit, it will appear that electrons are flowing through the circuit.

b. Electrons will not travel through the dielectric of a capacitor.

c. As the applied AC voltage increases and decreases in amplitude, the capacitor will charge and discharge.

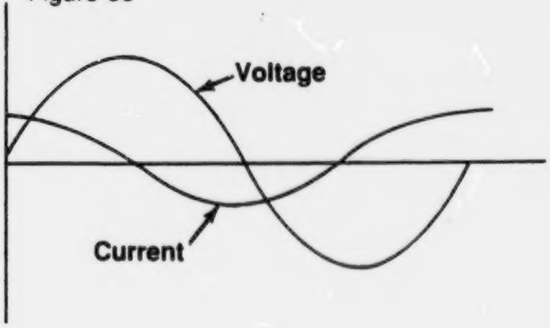
d. The movement of electrons from one plate to the other represents current flow.

e. Current and voltage do not flow in phase in a capacitive circuit: when the current is at its maximum, the voltage is at 0, thus the relationship is 90 degrees out of phase.

Information Sheet

f. The current leads the applied voltage in a capacitive circuit. (Figure 35)

Figure 35



g. After a capacitor is initially charged by an AC voltage, the voltage stored on the plates opposes any change in the applied voltage.

Note: This opposition to a change in voltage is known as *capacitive reactance.*

h. Capacitive reactance is represented as X_C, and is measured in ohms (Ω).

i. The formula for capacitive reactance is: $X_C = \frac{1}{2}\pi fC$.

Where:
$\pi = 3.14$
f = Frequency in Hertz
C = Capacitance in Farads

Example: What is the capacitive reactance of a 10-microfarad capacitor at 60 hertz?

Solution: $X_C = \frac{1}{2} \pi fc$

$= 1(2)(3.14)(60)(0.000010)$

$= 1/0.003768$

$= 265.39\Omega$

j. A capacitor is effective in controlling current in an AC circuit.

Information Sheet

k. The formula used to calculate current when the voltage and the capacitive reactance is known is: $I = E/X_C$.

Where:
I = Current
E = Voltage
X_C = Capacitive Reactance

Example: A 20-microfarad capacitor has 240 volts applied at 60 hertz. What is the value of the current flow through the circuit?

Solution: $X_C = ½\pi fC$

$= 1/(2)(3.14)(60)(0.000020)$

$= 1/0.007536$

$= 132.7\Omega$

Using X_C, it is now possible to calculate the current.

$I = E/X_C$

$= 240/132.7$

$= 1.81A$

l. Capacitors are commonly used for power factor correction.

16. Inductive AC circuits

a. In AC circuits, inductors offer opposition to current flow.

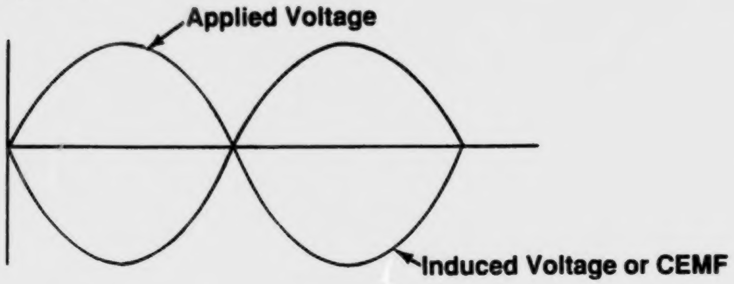
b. As an AC voltage is applied to an inductor or an inductive circuit, a magnetic field expands and collapses around the inductor.

c. This magnetic field induces a voltage in the windings of the inductor. This is called counter-electromotive force or CEMF. The CEMF is always less than the applied EMF.

Information Sheet

d. CEMF is an effective means of controlling current flow because it is 180 degrees out of phase of the applied voltage and opposes the applied voltage. (Figure 36)

Figure 36



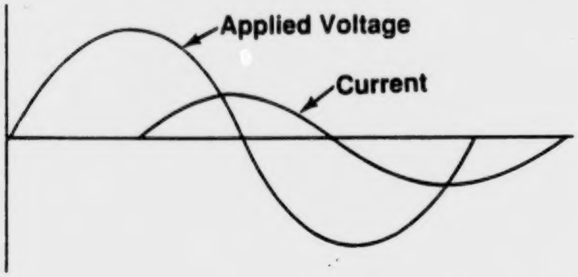
e. Opposition to current flow is known as *inductive reactance.*

f. Inductive reactance is a factor of the size of the inductor and the frequency of the applied voltage.

g. Inductive reactance is represented as X_L and is expressed in ohms (Ω).

h. Inductive reactance will lag the applied voltage in an AC circuit. (Figure 37)

Figure 37



Information Sheet

i. The formula for inductive reactance is: $X_L = 2\pi fL$.

Where:
$\pi = 3.14$
f = Frequency in Hertz
L = Inductance in Henries

Example: What is the inductive reactance of a 0.75-henry coil at 60 hertz?

Solution:
$$X_L = 2\pi fL$$
$$= (2)(3.14)(60)(0.75)$$
$$= 282.6\Omega$$

j. Current in an inductive reactive circuit can be calculated using the following formula: $I = E/X_L$.

Where:
I = Current
E = Voltage
X_L = Inductive Reactance

Example: How much current flows through a 0.25-henry inductor when 120 volts at 60 hertz is applied?

Solution:
$$X_L = 2\pi fL$$
$$= (2)(3.14)(60)(0.25)$$
$$= 94.20\Omega$$

Using X_L the current may now be calculated.

$$I = E/X_L$$
$$= 120/94.20$$
$$= 1.27A$$

k. The combination of both resistance and inductive reactance is called *impedance*.

l. Due to the phase shift, resistance and inductive reactance cannot be added directly.

m. Impedance is the vector sum of the inductive reactance and the resistance in the circuit.

n. Impedence is represented as Z and is expressed in ohms (Ω).

Information Sheet

o. Impedence is defined by Ohm's Law as: $I = E/Z$.

Where:
I = Current
E = Voltage
Z = Impedance

p. The most common inductive circuit consists of an inductor connected in series with a resistor. This iscalled an *RL circuit.*

q. The RL circuit may be expressed mathematically as: $Z = \sqrt{R^2 + X_L^2}$.

Example: What is the impedance of a 0.1-henry inductor in series with a 4,700-ohm resistor, with 240 volts at 60 hertz applied?

Solution:

$$X_L = 2\pi fL$$

$$= (2)(3.14)(60)(0.1)$$

$$= 37.68\Omega$$

Using X_L, it is now possible to calculate impedance.

$$Z = \sqrt{R^2 + X_L^2}$$

$$= \sqrt{(4700)^2 + (37.68)^2}$$

$$= \sqrt{22090000 + 1419.78}$$

$$= \sqrt{22091419.78}$$

$$= 4700.15\Omega$$

17. Characteristic of power in an AC circuit

a. In an AC circuit, voltage and current are seldom in phase.

Note: The exception would be incandescent lights and resistance heating circuits.

b. The power or product of voltage and current must be multiplied by a power factor to determine the true power.

Example: Power (Watts) = Volts × Amperes or $P = E \times I$

$$\text{(Power factor) PF} = \frac{\text{True Power}}{\text{Apparent Power}}$$

Information Sheet

c. By using a meter, one can determine the true power in a circuit.

Example: A voltmeter reads 120 volts and the ammeter reads 10 amps. A wattmeter gives a reading of 1,000 watts of true power.

Solution: $P = E \times I$

$= 120 \times 10 = 1200$ Watts of Apparent Power

$PF = \frac{1000}{1200}$ True Power

$= 83\%$ or .83

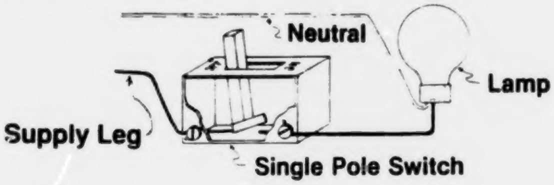
Note: For three-phase circuits, the product of the voltage and amperage must be multipled by $\sqrt{3}$.

18. **Basic switching circuits used in electricity** (Figures 38-40)

a. Single-pole switch

Note: A single-pole switch breaks the circuit only in one position.

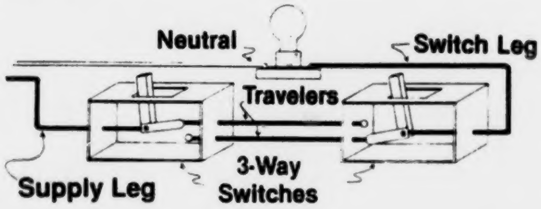
Figure 38


Neutral
Lamp
Supply Leg
Single Pole Switch

b. Three-way switch

Note: A three-way switch breaks the circuit in two positions.

Figure 39

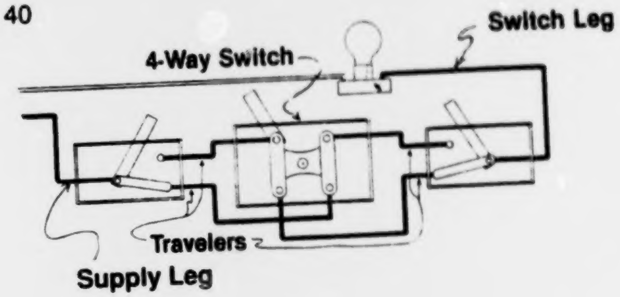

Neutral
Switch Leg
Travelers
3-Way Switches
Supply Leg

Information Sheet

c. Four-way switch

Note: When wired with two three-way switches, as many four-way switches can be installed as needed, making the operation from many positions.

Figure 40


Switch Leg
4-Way Switch
Travelers
Supply Leg

AC Circuits
Unit 10

Assignment Sheet 1—Solve Power Factor Problems

Name ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
Assignment answers complete	______
Minimum of seven of eight answers correct per Answers to Assignment Sheet 1	______

Directions: Find the power factor for the following problems. Show calculations in the space provided below each answer.

A. A voltmeter reads 200 volts and an ammeter reads 10 amps. The wattmeter has a reading of 1,400 watts. What is the power factor? ____________

B. What is the power factor on a device having 150 volts, 14 amps, and a watt reading of 1,600 watts? ____________

C. What is the power factor on a device with a 120-volt and 12-amp rating on a circuit and a true power of 1,200 watts? ____________

D. What is the power factor when the true power on a circuit is 1,400 watts and the apparent power is 2,000 watts? ____________

E. What is the power factor when the true power on a circuit is 1,700 watts and the apparent power is 2,000 watts? ____________

F. A three-phase 480-volt circuit is pulling 250 amps. A wattmeter reads 13.9 kilowatts. What is the power factor? ____________

Assignment Sheet 1

G. A 240-volt, three-phase motor is pulling 15 amps. The wattmeter reads 6 kilowatts. What is the motor's power factor? ____________

H. Twenty amperes are drawn by a 208-volt, three-phase circuit. A wattmeter records 6.35 kilowatts. What is the power factor? ____________

AC Circuits
Unit 10

Assignment Sheet 2—Solve RC and RL Circuit Problems

Name ________________________________ Overall Rating __________

Evaluation criteria	Rating
Assignment answers complete	______
Minimum of four of five answers correct per Answers to Assignment Sheet 2	______

Directions: Using the formulas given in Sections 15 and 16 of the Information Sheet for RC and RL circuits, solve the following problems. Show calculations in the space provided below each answer.

A. A 0.3-farad capacitor is operating on a 60-hertz AC signal. What will be its capacitive reactance? __________

B. A 200-microfarad capacitor is connected to a 208-volt circuit at 60 hertz. What is the current in the circuit? __________

C. What is the inductive reactance of a 350-millihenry choke at 60 hertz? __________

Assignment Sheet 2

D. What is the current flow through a 500-millihenry choke when 100 volts at 60 hertz is applied? ____________

E. What is the impedance of a 600-millihenry inductor in series with 2,200Ω, with 480 volts at 60 hertz applied? ____________

AC Circuits
Unit 10

Assignment Sheet 3—Draw a Diagram of a Single-Pole Switch on a Light

Name ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
All connections indicated	______
Correct symbols used	______
Circuit wiring correct conficuration per Answers to Assignment Sheet 3	______

Directions: In the space provided, draw a diagram of a single-pole switch on a light.

AC Circuits
Unit 10

Assignment Sheet 4—Draw a Diagram of Two Three-Way Switches on a Light

Name ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
All connections indicated	_____
Correct symbols used	_____
Circuit wiring correct configuration per Answers to Assignment Sheet 4	_____

Directions: In the space provided, draw a diagram of two three-way switches on a light.

AC Circuits
Unit 10

Assignment Sheet 5—Draw a Diagram of Two Three-Way Switches and a Four-Way Switch on a Light

Name ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
All connections indicated	_____
Correct symbols used	_____
Circuit wiring correct per Answers to Assignment Sheet 5	_____

Directions: In the space provided, draw a diagram of two three-way switches and a four-way switch on a light.

AC Circuits
Unit 10

Job Sheet 1—Wire a Single-Pole Switch Controlling a Single Lighting Outlet with the Supply Line Entering the Switch Box

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Gathered and used appropriate equipment and materials	______
Performed procedure safely	______
Performed all steps in procedure	______
Cleaned work area	______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the above criteria.

A. Equipment and materials

- 12-2-G or 14-2-G NM cable
- Device box
- Nonmetallic octagon box with *NEC* capacity rating to accommodate the conductors you will install
- Staples
- Single-pole switch
- Light socket
- Bar hanger (if not using a bracket octagon box or installing this job on a work board)
- Stud wall or work board
- 120-volt supply (The overcurrent supply should not exceed your conductors' *NEC* ampacity rating.)
- ⅜-inch cable clamp to fit a ½-inch knockout
- 120-volt incandescent bulb
- Portable GFCI
- Wire connectors (Twist-on connectors will be used in this manual for illustrations. Wire connectors, pressure connectors, or solder would also be acceptable in the trade.)
- Two 16-penny nails
- Two plasterboard nails
- Electrician's hammer
- Plain-tip screwdriver
- Long-nose pliers
- Lineman's pliers
- Pocket knife
- Wire strippers
- Tool pouch
- Drill motor or brace
- ½-inch or larger wood bit for hole large enough to safely accommodate cable
- Extension cord
- Safety glasses

Job Sheet 1

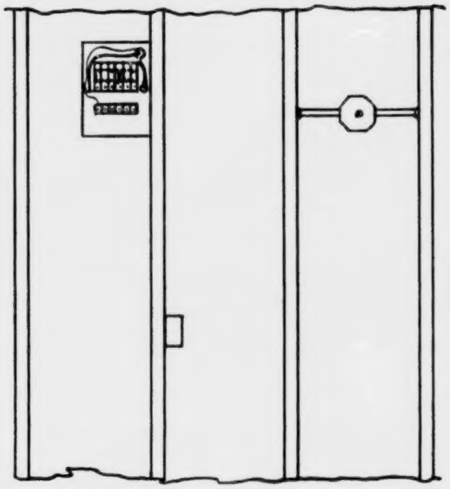
B. Procedure

☐ 1. Put on safety glasses and gather equipment and materials.

☐ 2. Mount boxes. (Figure 1)

Note: The switch box and ceiling outlet can be mounted at any height in this project.

Figure 1



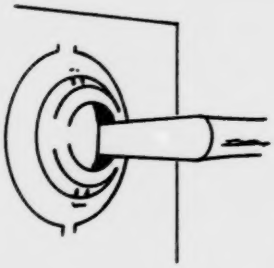
3. Remove a ½-inch knockout from the panel.

☐ a. Locate ½-inch knockout to be removed.

Job Sheet 1

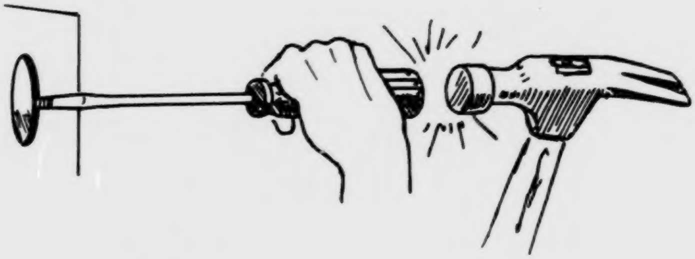
☐ b. Place screwdriver on KO at point opposite unstamped piece. (Figure 2)

Figure 2



☐ c. Hit screwdriver handle crisply with hammer. (Figure 3)

Figure 3

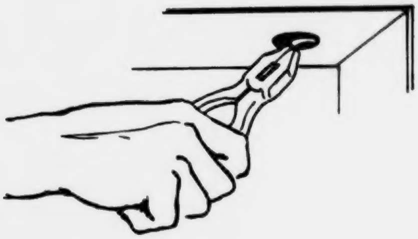


☐ d. Grasp raised KO with lineman's pliers.

Job Sheet 1

☐ e. Bend KO back and forth until removed. (Figure 4)

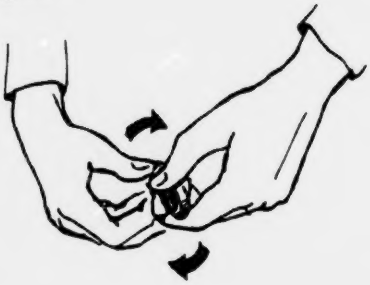
Figure 4



4. Install cable connector.

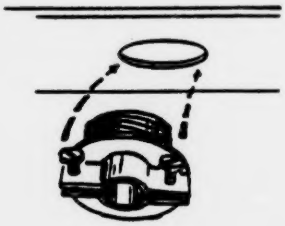
☐ a. Hold connector and unscrew locknut. (Figure 5)

Figure 5



☐ b. Place threads through KO opening. (Figure 6)

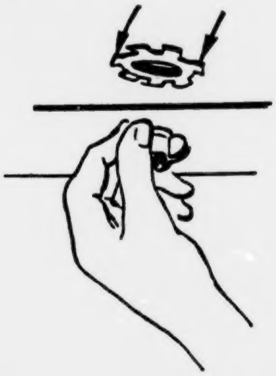
Figure 6



Job Sheet 1

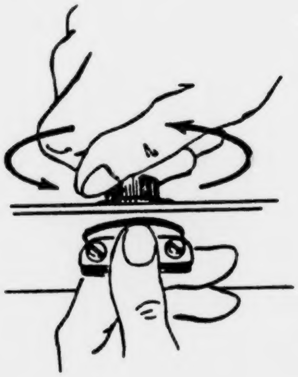
☐ c. Install locknut. (Figure 7)

Figure 7



☐ d. Tighten locknut, making sure serrated teeth are in contact with box. (Figure 8)

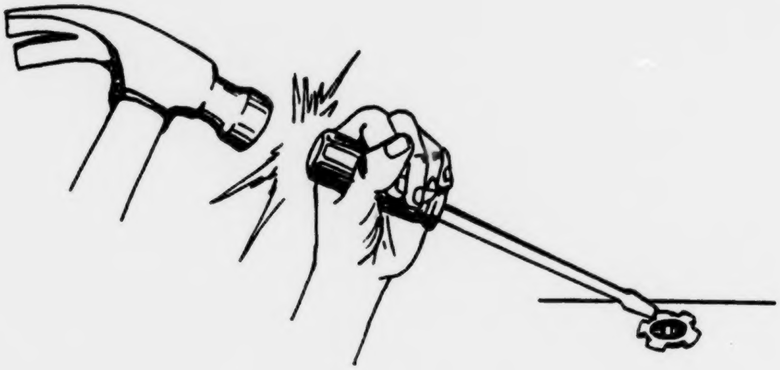
Figure 8



Job Sheet 1

☐ e. Tighten locknut securely. (Figure 9)

Figure 9



☐ 5. Plug cord into portable GFCI.

☐ 6. Bore holes for cable.

Note: Holes should be drilled as close to the center (front and back) of a stud as possible. Holes should be drilled at least 6 inches above or below the box, depending on which route is the closest.

Caution: Be sure to hold the drill securely. A loose grip can cause an accident.

7. Run cable.

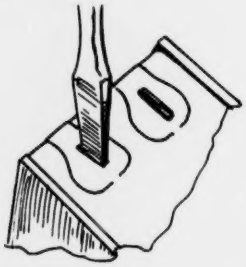
   a. Remove KO's from boxes.

Job Sheet 1

☐ (1) Place screwdriver in slot. (Figure 10)

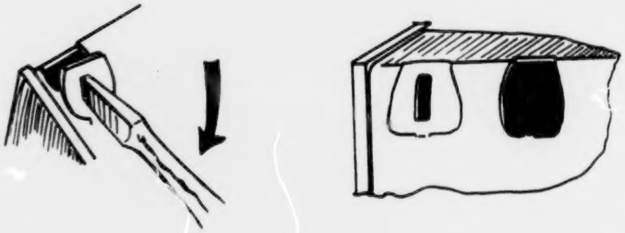
Note: This is for metallic boxes; most nonmetallic boxes have KOs that are broken out by placing a screwdriver in the center and hitting it with your hand or hammer.

Figure 10



☐ (2) Pry out KO. (Figure 11)

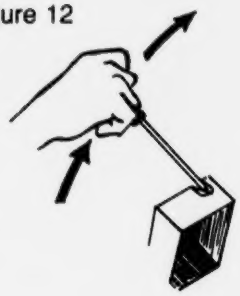
Figure 11



Job Sheet 1

☐ (3) Wiggle screwdriver until KO pops loose. (Figure 12)

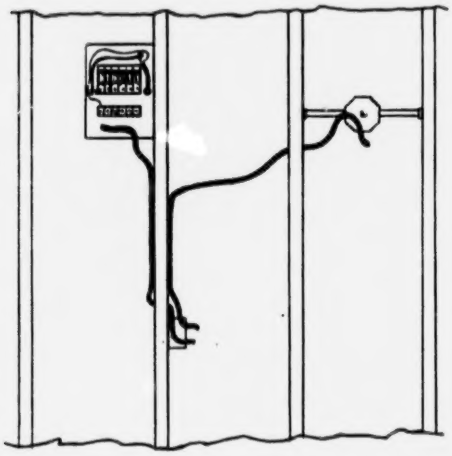
Figure 12



☐ b. Run cable between boxes. (Figure 13)

Note: Leave at least 8 inches extending past the surface of the device and the lighting outlet boxes, and enough to reach the top of the panel, plus half of the width.

Figure 13



☐ 8. Staple cable within 12 inches of all metallic boxes, 8 inches of all nonmetallic boxes.

Note: Cables should be run flat when possible.

Job Sheet 1

☐ 9. Secure all cable clamps and connectors.

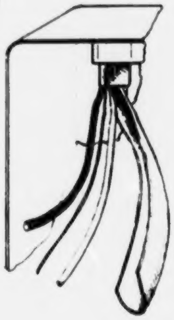
Caution: Tighten clamps and connectors only until the cable will not slip in the box; overtightening can cause an electrical short.

☐ 10. Strip cable insulation to within ¼ inch of its point of entry. (Figure 14)

Note: Refer to *NEC*, Art. 300-14. Cables should be stripped before they are installed in the boxes.

Caution: Extreme care should always be used in operations involving the knife; a cut hand can cause pain and lost work time.

Figure 14

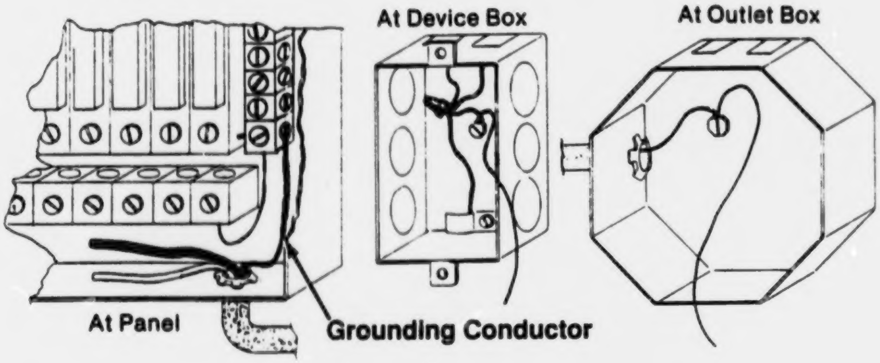


Job Sheet 1

☐ 11. Connect all grounding conductors (green or bare). (Figure 15)

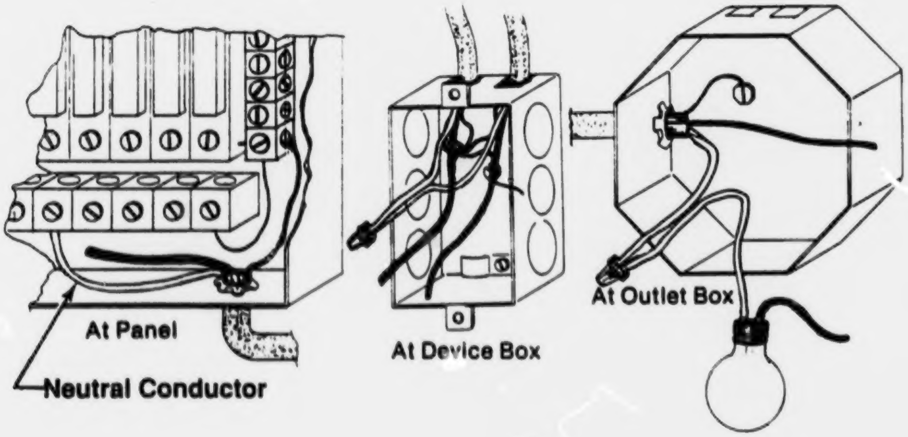
Note: Always leave enough conductor to make removal and connection easy. *NEC* requires at least 6 inches of free conductor leaving the face of the box.

Figure 15


At Device Box
At Outlet Box
At Panel
Grounding Conductor

☐ 12. Connect all neutral conductors (white or natural gray). (Figure 16)

Figure 16


At Outlet Box
At Panel
At Device Box
Neutral Conductor

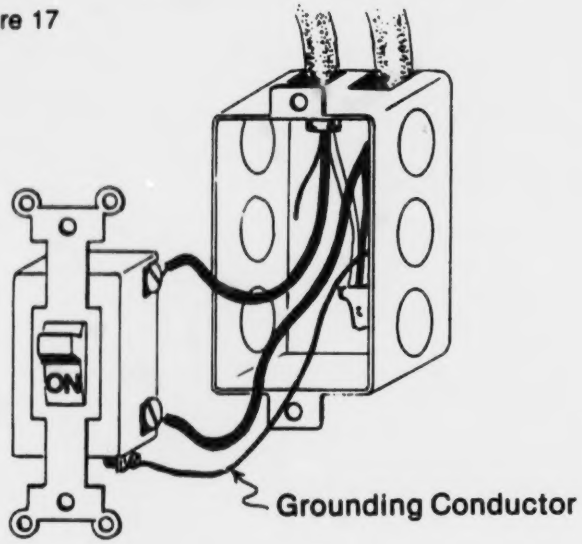
☐ 13. Connect switch leg to remaining lampholder, conductor, or terminal.

Job Sheet 1

☐ 14. Connect switch. (Figure 17)

Note: Be sure that the loop in the conductors is turned in the direction that the terminal tightens, and connect neutrals together with a wire nut.

Figure 17



☐ 15. Install the switch in box.

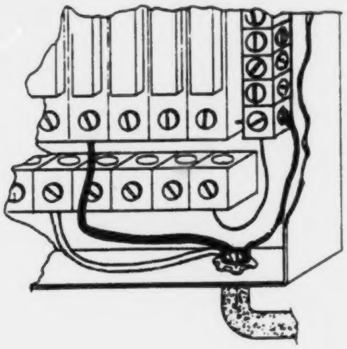
Note: Be sure and push all conductors into the box; do not rely on the installation of the switch to situate them.

Job Sheet 1

☐ 16. Connect ungrounded conductor to appropriate overcurrent device. (Figure 18)

> **Caution: Be sure that the breaker is off or the fuse is out before connecting this conductor. Always be safety conscious when working inside a panel.**

Figure 18



☐ 17. Move single-pole to "off" position.

☐ 18. Turn on breaker.

> **Caution: Stand to the side of the panel when turning on the breaker. A short in the circuit could cause molten metal to fly from the panel.**

☐ 19. Turn on switch.

Note: Have your instructor evaluate this project.

☐ 20. Turn breaker off.

☐ 21. Clean work area, and return equipment and materials to proper storage.

Evaluator's comments: ______________________________

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AC Circuits
Unit 10

Job Sheet 2—Wire a Single-Pole Switch Controlling a Single Lighting Outlet with the Supply Line Entering the Lighting Outlet Box

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation criteria	**Rating**
Gathered and used appropriate equipment and materials	______
Performed procedure safely	______
Performed all steps in procedure	______
Cleaned work area	______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the above criteria.

A. Equipment and materials

- 12-2-G or 14-2-G NM cable
- Device box
- Nonmetallic octagon box with *NEC* capacity rating to accommodate the conductors you will install
- Staples
- Single-pole switch
- Light socket
- Bar hanger (if not using a bracket octagon box or installing this job on a work board)
- Stud wall or work board
- 120-volt supply (The overcurrent supply should not exceed your conductors' *NEC* ampacity rating.)
- ⅜-inch cable clamp to fit a ½-inch knockout
- 120-volt incandescent bulb
- Portable GFCI
- Wire connectors (Twist-on connectors will be used in this manual for illustrations. Wire connectors, pressure connectors, or solder would also be acceptable in the trade.)
- Two 16-penny nails
- Two plasterboard nails
- Electrician's hammer
- Plain-tip screwdriver
- Long-nose pliers
- Lineman's pliers
- Pocket knife
- Wire strippers
- Tool pouch
- Drill motor or brace
- ½-inch or larger wood bit for hole large enough to safely accommodate cable
- Extension cord
- Safety glasses

Job Sheet 2

B. Procedure

☐ 1. Put on safety glasses and gather equipment and materials.

☐ 2. Mount boxes.

Note: The switch box and ceiling outlet can be mounted at any height in this project.

☐ 3. Remove a ½-inch knockout from the panel.

☐ 4. Install cable connector.

☐ 5. Plug cord into portable GFCI.

☐ 6. Bore holes for cable.

Note: Holes should be drilled as close to the center (front and back) of a stud as possible. Holes should be drilled at least 6 inches above or below the box, depending on which route is the closest.

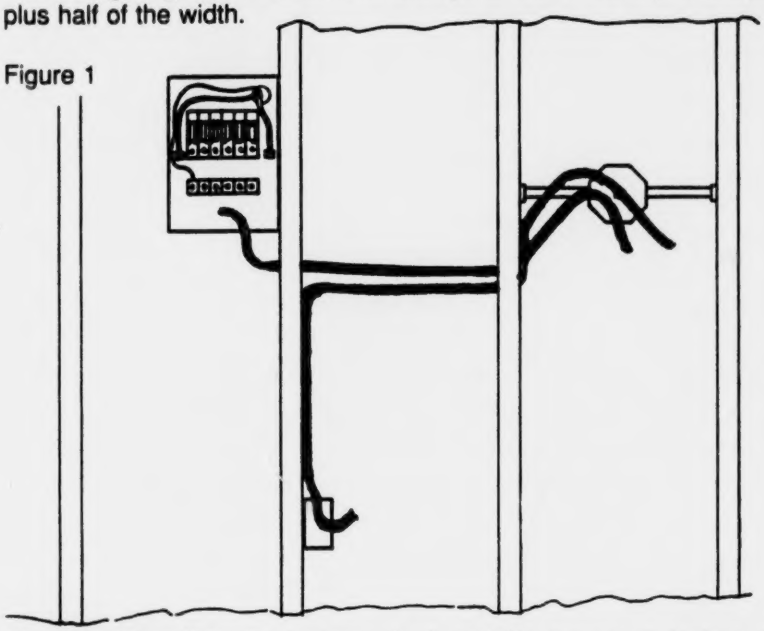
Caution: Be sure to hold the drill securely. A loose grip can cause an accident.

Job Sheet 2

☐ 7. Run cable.

Note: Leave at least 8 inches extending past the surface of the device and the lighting outlet boxes, and enough to reach the top of the panel, plus half of the width.

Figure 1



☐ 8. Staple cable within 12 inches of all metallic boxes; 8 inches of all nonmetallic boxes.

☐ 9. Secure all cable clamps and connectors.

Caution: Tighten clamps and connectors only until the cable will not slip in the box; overtightening can cause an electrical short.

☐ 10. Strip cable insulation to within ¼ inch of its point of entry. (Figure 14)

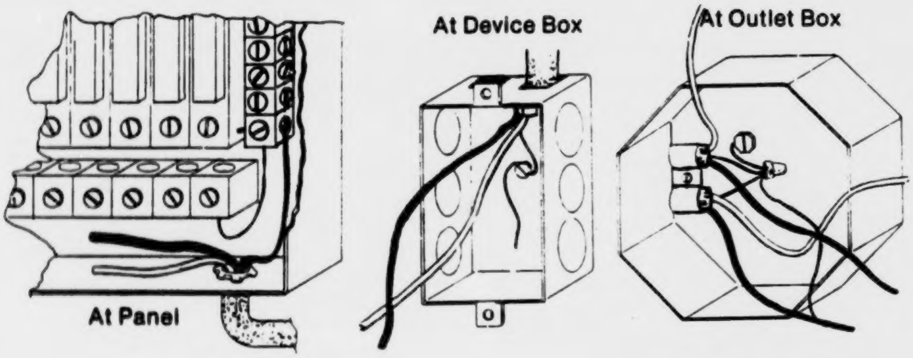
Caution: Extreme care should always be used in operations involving the knife; a cut hand can cause pain and lost work time.

Job Sheet 2

☐ 11. Connect all grounding conductors (green or bare). (Figure 2)

Note: Always leave enough conductor to make removal and connection easy. *NEC* requires at least 6 inches of free conductor leaving the face of the box.

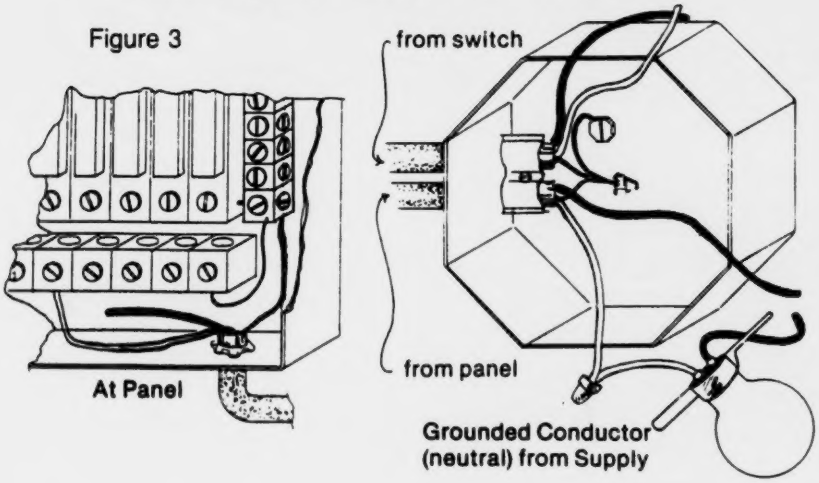
Figure 2


At Panel
At Device Box
At Outlet Box

☐ 12. Connect all neutral conductors (white or natural gray). (Figure 3)

Note: The grounded conductor in this circuit goes from the grounded terminal of the panel to the light, where it stops.

Figure 3

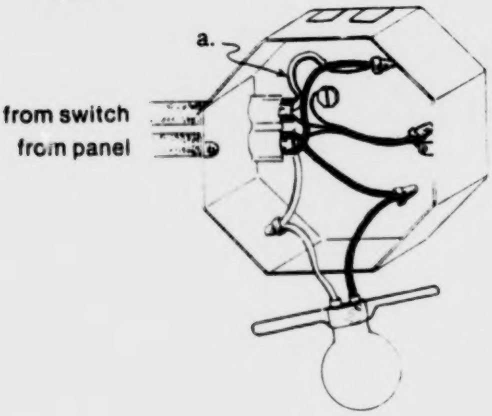

from switch
from panel
At Panel
Grounded Conductor
(neutral) from Supply

Job Sheet 2

☐ 13. Make up outlet box. (Figure 4)

Note: In switching situations the technician is allowed to use the white or gray conductor as the hot feed to the switch.

Figure 4



☐ 14. Install conductors on switch.

Note: It makes no difference which terminals the white and black conductors go on. The grounding, however, must go on the green, hex-head screw.

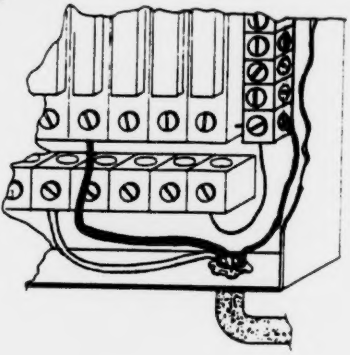
☐ 15. Install switch in box.

Job Sheet 2

☐ 16. Connect ungrounded conductor to appropriate overcurrent protective device. (Figure 5)

Caution: Be sure that the breaker is off or the fuse is out before connecting this conductor. Always be safety conscious when working inside a panel.

Figure 5



☐ 17. Move single-pole to "off" position.

☐ 18. Turn on breaker.

Caution: Stand to the side of the panel when turning on the breaker. A short in the circuit could cause molten metal to fly from the panel.

☐ 19. Turn on switch.

Note: Have your instructor evaluate this project.

☐ 20. Turn breaker off.

☐ 21. Clean work area, and return equipment and materials to proper storage.

Evaluator's comments: ____________________

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____

AC Circuits
Unit 10

Job Sheet 3—Wire a Three-Way Switching Situation with the Supply Line Entering a Single Lighting Outlet

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	Rating
Gathered and used appropriate equipment and materials	______
Performed procedure safely	______
Performed all steps in procedure	______
Cleaned work area	______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the above criteria.

A. Equipment and materials

- 12-2-G or 14-2-G and 12-3-G or 14-3-G NM cable
- Two device boxes
- Nonmetallic octagon box with *NEC* capacity rating to accommodate the conductors you will install
- Staples
- Two 3-way switches
- Light socket
- Bar hanger (if not using a bracket octagon box or installing this job on a work board)
- Stud wall or work board
- 120-volt supply (The overcurrent supply should not exceed your conductors' *NEC* ampacity rating.)
- ⅜-inch cable clamp
- 120-volt incandescent bulb
- Portable GFCI
- Wire connectors (Twist-on connectors will be used in this manual for illustrations. Wire connectors, pressure connectors, or solder would also be acceptable in the trade.)
- Two 16-penny nails
- Two plasterboard nails
- Electrician's hammer
- Plain-tip screwdriver
- Lineman's pliers
- Needle-nose pliers
- Pocket knife
- Wire strippers
- Tool pouch
- Drill motor or brace
- ½-inch or larger wood bit for hole large enough to safely accommodate cable
- Extension cord
- Safety glasses

Job Sheet 3

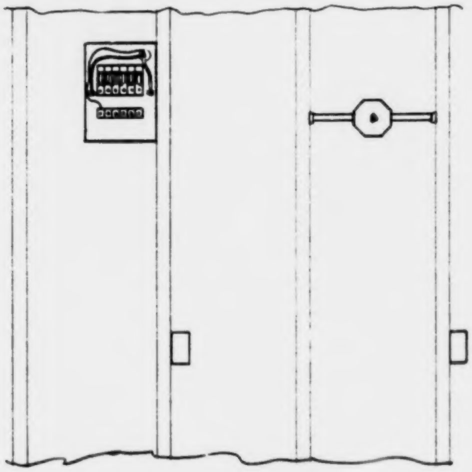
B. Procedure

☐ 1. Gather equipment and materials.

☐ 2. Mount boxes. (Figure 1)

Note: The switch box and ceiling outlet can be mounted at any height in this project.

Figure 1



☐ 3. Remove a ½-inch knockout from the panel.

☐ 4. Install cable connector.

☐ 5. Plug cord into GFCI.

☐ 6. Bore holes for cable.

Note: Holes should be drilled as close to the center (front and back) of a stud as possible. Holes should be drilled at least 6 inches above or below the box, depending on which route is the closest.

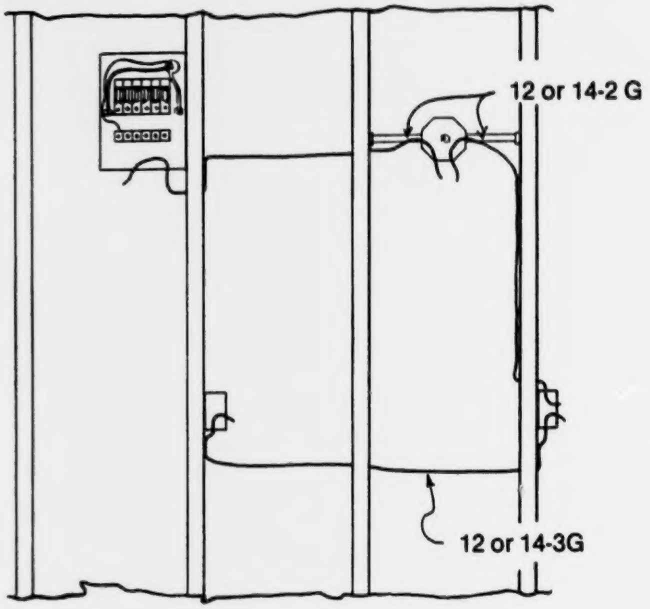
> **Caution: Be sure to hold the drill securely. A loose grip can cause an accident.**

Job Sheet 3

☐ 7. Run cable. (Figure 2)

Note: Leave at least 8 inches extending past the surface of the device and the lighting outlet boxes, and enough to reach the top of the panel, plus half of the width.

Figure 2



☐ 8. Staple cable within 12 inches of all metal boxes, 8 inches of all nonmetallic boxes.

☐ 9. Secure all cable clamps and connectors.

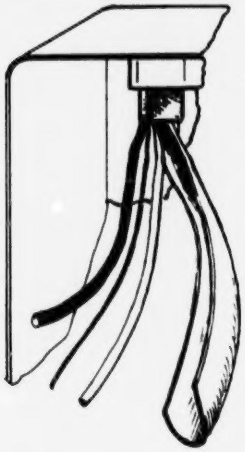
Caution: Tighten clamps and connectors only until the cable will not slip in the box; overtightening can cause an electrical short.

Job Sheet 3

☐ 10. Strip cable insulation to within ¼ inch of its point of entry. (Figure 3)

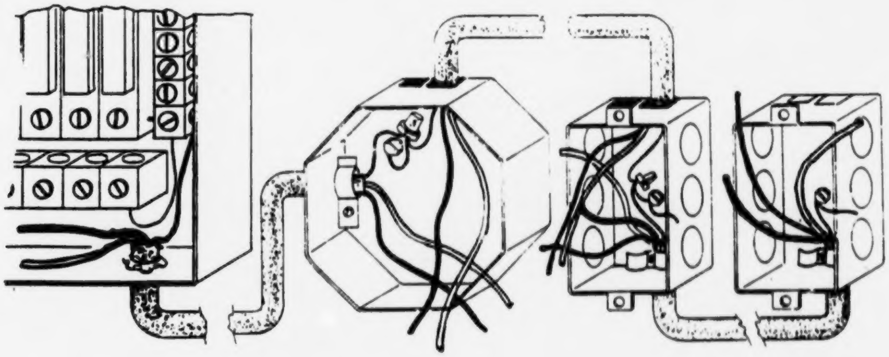
Caution: Extreme care should always be used in operations involving the knife; a cut hand can cause pain and lost work time.

Figure 3



☐ 11. Connect all grounding conductors. (Figure 4)

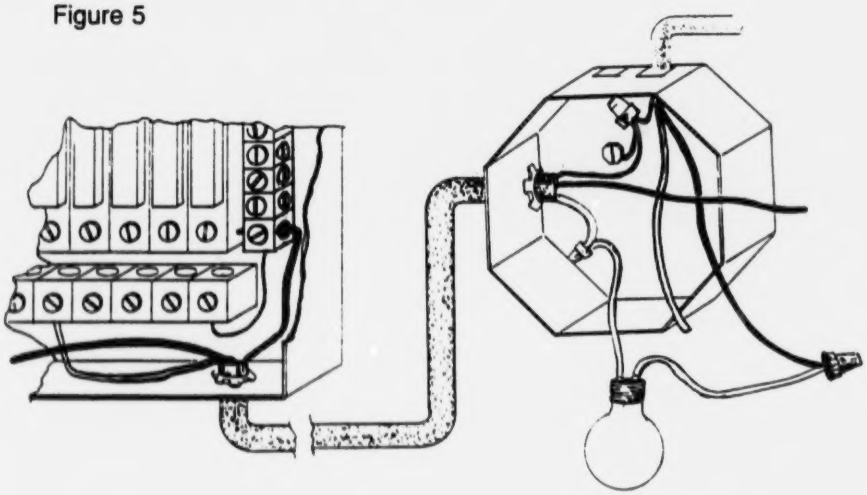
Figure 4



Job Sheet 3

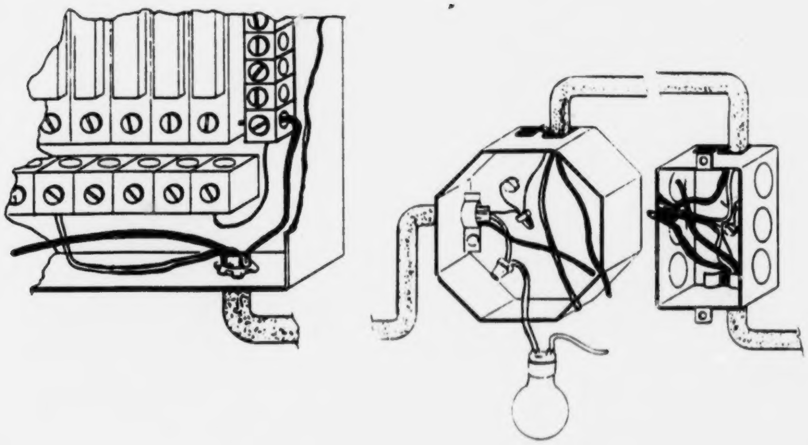
☐ 12. Connect all neutral conductors. (Figure 5)

Figure 5



☐ 13. Connect switch legs. (Figure 6)

Figure 6

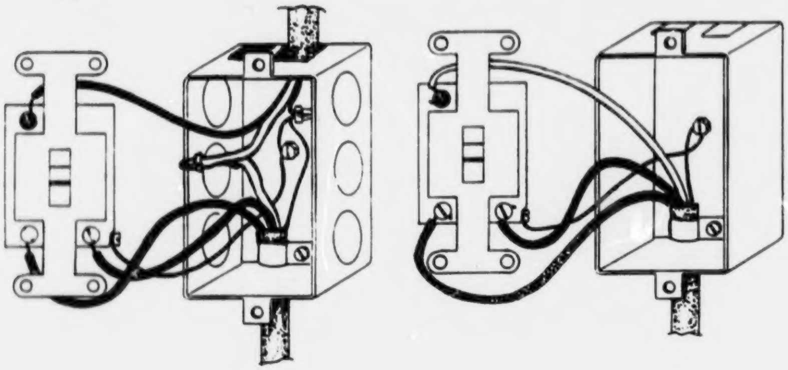


Job Sheet 3

☐ 14. Install switches. (Figure 7)

Note: In all three-way circuits, the switch leg ties to one common terminal, and the hot conductor ties to the other common terminal. The remaining terminals connect to the traveler conductors. The grounding screw attaches to the grounding conductor, and then to the green hex-head screw.

Figure 7



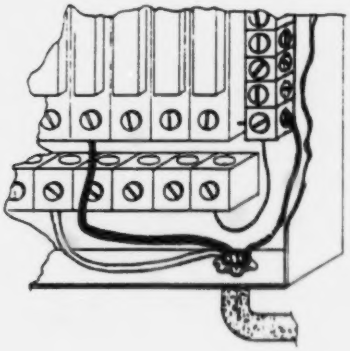
☐ 15. Connect return leg to socket.

Job Sheet 3

☐ 16. Connect ungrounded conductor to appropriate overcurrent protective device. (Figure 8)

Caution: Be sure that the breaker is off or the fuse is out before connecting this conductor. Always be safety conscious when working inside a panel.

Figure 8



☐ 17. Turn on breaker.

Caution: Stand to the side of the panel when turning on the breaker. A short in the circuit could cause molten metal to fly from the panel.

☐ 18. Change the position of the switches in alternating movements.

Note: Be sure that you can turn the light on or off from either switch, as well as on at one and off at the other. Have your instructor evaluate this project.

☐ 19. Turn breaker off.

☐ 20. Clean work area, and return equipment and materials to proper storage.

Evaluator's comments: ______________________________

____

____

AC Circuits
Unit 10

Job Sheet 4—Wire a Four-Way Switching Situation with the Supply Line Entering the Lighting Outlet Box

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation criteria	**Rating**
Gathered and used appropriate equipment and materials	______
Performed procedure safely	______
Performed all steps in procedure	______
Cleaned work area	______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the above criteria.

A. Equipment and materials

- 12-2-G or 14-2-G and 12-3-G or 14-3-G NM cable
- Three device boxes
- Nonmetallic octagon box with *NEC* capacity rating to accommodate the conductors you will install
- Staples
- Two 3-way switches
- One 4-way switch
- Light socket
- Bar hanger (if not using a bracket octagon box or installing this job on a work board)
- Stud wall or work board
- 120-volt supply (The overcurrent supply should not exceed your conductors' *NEC* ampacity rating.)
- ⅜-inch cable clamp
- 120-volt incandescent bulb
- Portable GFCI
- Wire connectors (Twist-on connectors will be used in this manual for illustrations. Wire connectors, pressure connectors, or solder would also be acceptable in the trade.)
- Two 16-penny nails
- Two plasterboard nails
- Electrician's hammer
- Plain-tip screwdriver
- Lineman's pliers
- Needle-nose pliers
- Pocket knife
- Wire strippers
- Tool pouch
- Drill motor or brace
- ½-inch or larger wood bit for hole large enough to safely accommodate cable
- Extension cord
- Safety glasses

Job Sheet 4

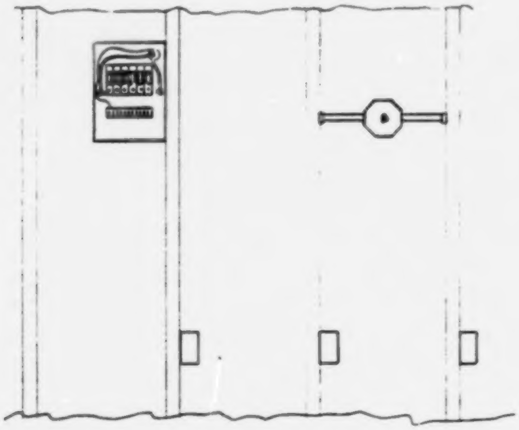
B. Procedure

☐ 1. Put on safety glasses and gather equipment and materials.

☐ 2. Mount boxes. (Figure 1)

Note: See instructor for location.

Figure 1



☐ 3. Remove a ½-inch knockout from the panel.

☐ 4. Install cable connector.

☐ 5. Plug cord into GFCI.

☐ 6. Bore holes for cable.

Note: Holes should be drilled as close to the center (front and back) of a stud as possible. Holes should be drilled at least 6 inches above or below the box, depending on which route is the closest.

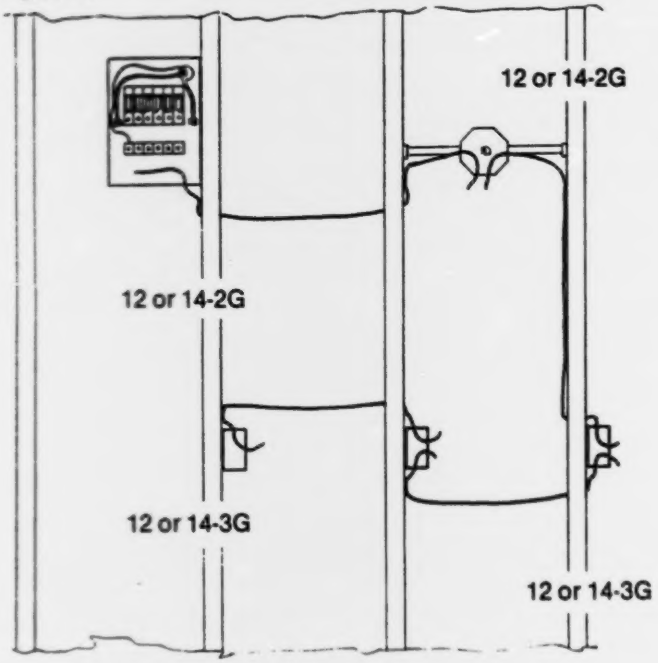
Caution: Be sure to hold the drill securely. A loose grip can cause an accident.

Job Sheet 4

☐ 7. Run cable. (Figure 2)

Note: Leave at least 8 inches extending past the surface of the device and the lighting outlet boxes, and enough to reach the top of the panel, plus half of the width.

Figure 2



☐ 8. Staple cable within 12 inches of all metal boxes, 8 inches of all nonmetallic single-gang boxes.

Note: Refer to *NEC*, Art. 336-15.

☐ 9. Secure all cable clamps and connectors.

Caution: Tighten clamps and connectors only until the cable will not slip in the box; overtightening can cause an electrical short.

Job Sheet 4

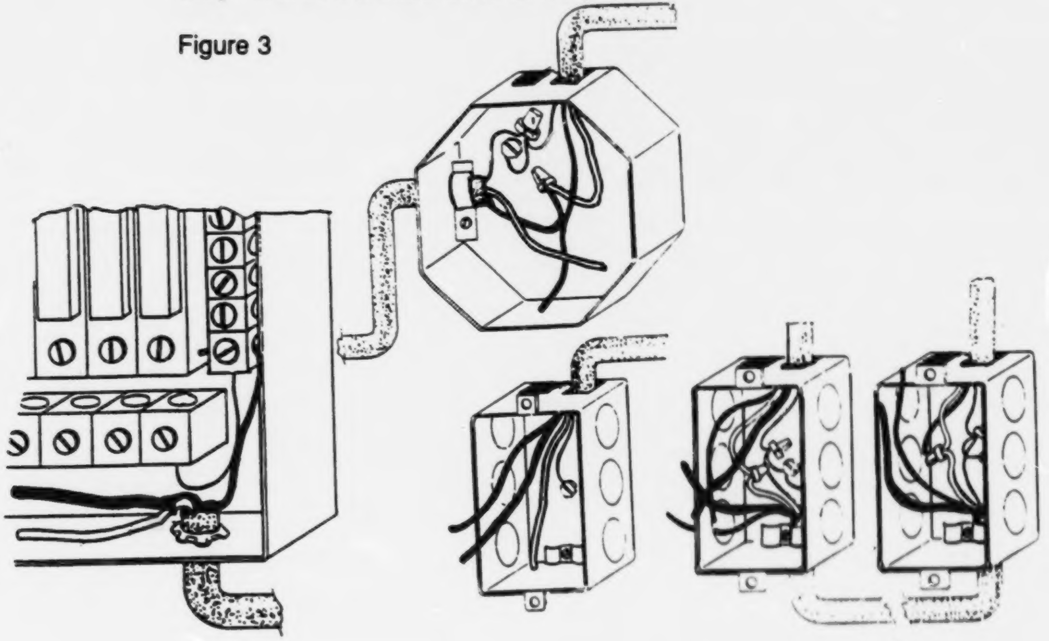
☐ 10. Strip cable insulation to within ¼ inch of its point of entry.

> **Caution: Extreme care should always be used in operations involving the knife; a cut hand can cause pain and lost work time.**

☐ 11. Connect all grounding conductors. (Figure 3)

Note: Always leave enough conductor to make removal and reconnection easy. Notice the extra bend at the panel.

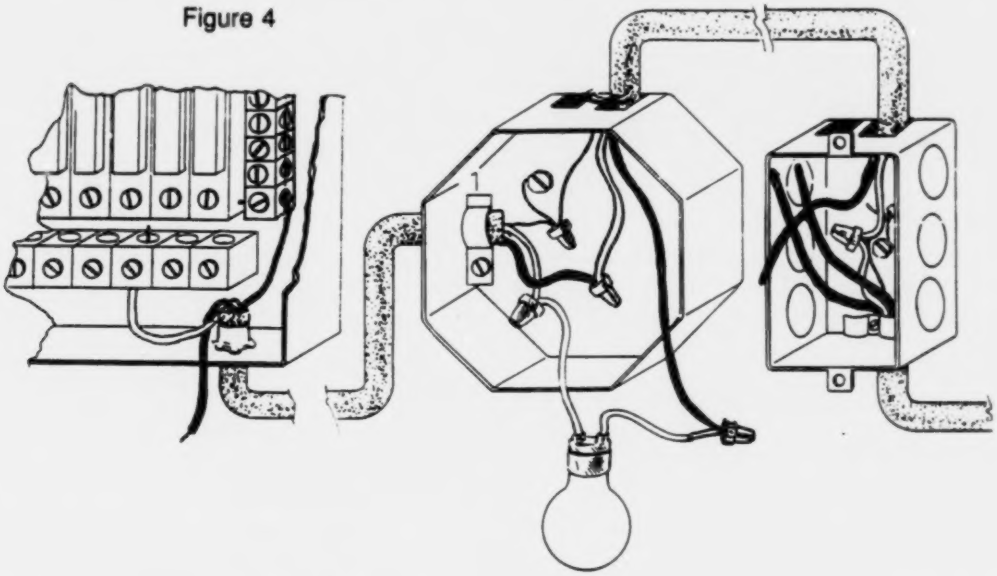
Figure 3



Job Sheet 4

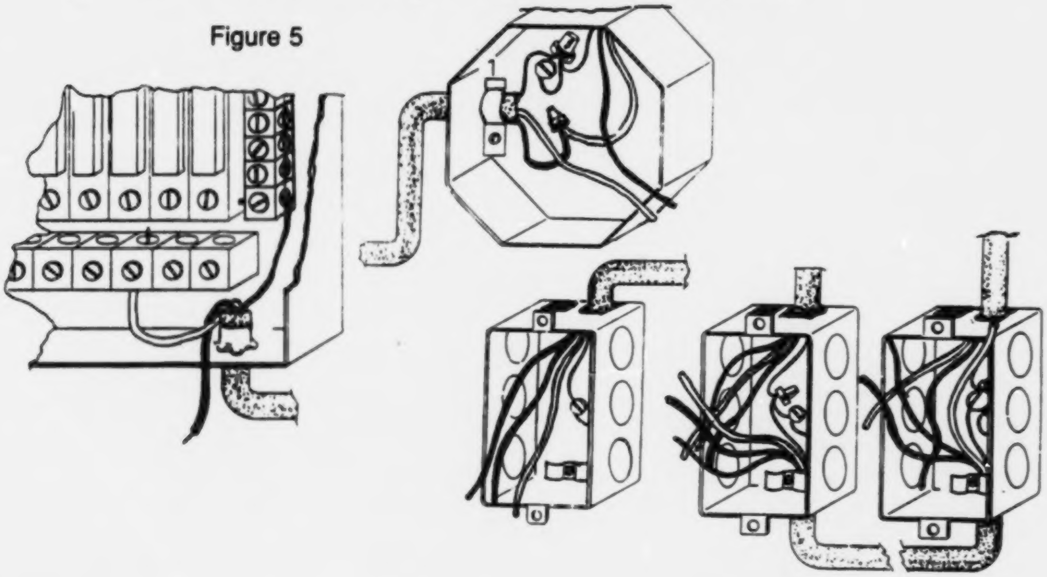
☐ 12. Connect all neutral conductors. (Figure 4)

Figure 4



☐ 13. Connect switch legs through the system. (Figure 5)

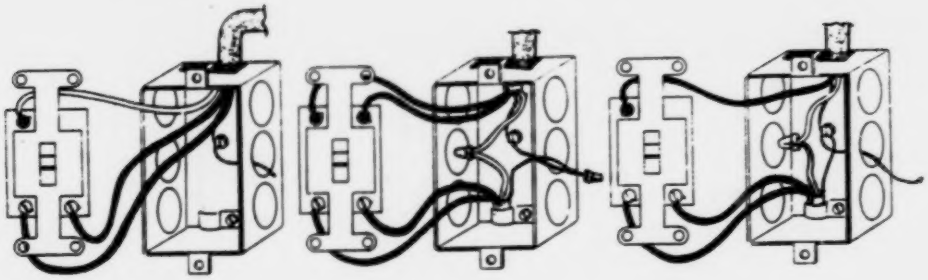
Figure 5



Job Sheet 4

☐ 14. Install switches. (Figure 6)

Figure 6

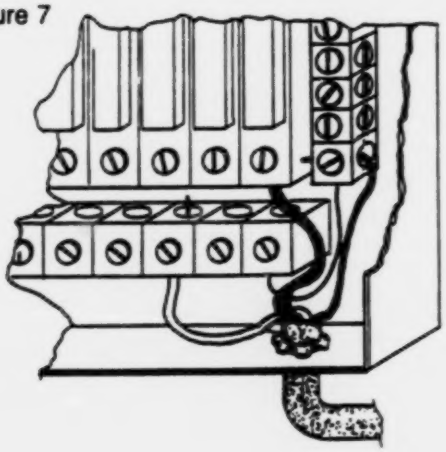


☐ 15. Connect switch leg to socket.

☐ 16. Connect ungrounded conductor to appropriate overcurrent protective device. (Figure 7)

Caution: Be sure that the breaker is off or the fuse is out before connecting this conductor. Always be safety conscious when working inside a panel.

Figure 7



Job Sheet 4

☐ 17. Turn on breaker.

Caution: Stand to the side of the panel when turning on the breaker. A short in the circuit could cause molten metal to fly from the panel.

☐ 18. Change the position of the switches in alternating movements.

Note: Be sure that you can turn the light on or off from either switch, as well as on at one and off at the other. Have your instructor evaluate this project.

☐ 19. Turn off breaker.

☐ 20. Clean work area, and return equipment and materials to proper storage.

Evaluator's comments: ______________________________________

____

____

Wiring Methods
Unit 11

Objective Sheet

Unit Objective

After completing this unit, the student should be able to identify wiring methods and their common applications. The student should demonstrate these competencies by completing the assignment sheet, job sheets, and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to wiring methods with their correct definitions.
2. Identify wiring methods found in electrical trades.
3. Match wiring methods with their common applications.
4. Reference the *National Electrical Code* to identify uses of wiring methods. (Assignment Sheet 1)
5. Install a set-screw conduit fitting. (Job Sheet 1)
6. Install a compression-type conduit fitting. (Job Sheet 2)
7. Braid the ground conductor of a service entrance cable. (Job Sheet 3)
8. Install an ENT coupling and connector on ENT conduit. (Job Sheet 4)

Wiring Methods
Unit 11

Suggested Activities

Instructional Plan

Preparation

1. Read the unit carefully and plan for instruction. Study the specific objectives to determine the order in which you will present them.

2. Review Teaching Suggestions section that follows. Plan for classroom activities.

3. Plan your presentation to take advantage of student learning styles and to accommodate special needs students.

4. Develop teaching plan. Adjust for different learning styles.

5. Make copies of Unit Evaluation Form.

Delivery and Application

6. Provide students with unit of instruction.

7. Discuss unit and specific objectives.

8. Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic skills when applicable.

9. Discuss the assignment sheets and schedule due dates. Review criteria for evaluation of these activities.

10. Discuss and demonstrate the job sheets. Review criteria for evaluation of these activities. Schedule performance dates.

Evaluation

11. Discuss the use of the Unit Evaluation Form with students. Discuss the rating scale that will be used for student evaluation.

12. Make copies of the written test. Add or modify test items as needed.

13. Give written test.

14. Compile assignment sheet and job sheet ratings and written test scores on the Unit Evaluation Form. Include any additional assignments.

Suggested Activities

15. Reteach and retest as required.

16. Meet individually with students to evaluate their progress throughout this unit of instruction, and indicate to them possible areas of improvement.

Teaching Suggestions

Note: Skill areas appearing in boldface type in the Teaching Suggestions refer to the academic and workplace skills identified by the American Society for Training and Development (ASTD) and the U.S. Department of Labor. These have been adapted by MAVCC.

1. Take students on a field trip to a local electrical supply house. Skill area: **Learning to learn**.

2. Invite a local inspector to talk to the class about various wiring methods. Skill area: **Listening**

3. Have a journeyman demonstrate wiring methods.

4. Have students report on articles dealing with wiring methods. Skill areas: **Writing, critical thinking**

Resources Used in Developing This Unit

1. Earley, Mark W., John M. Caloggero, and Richard H. Murray. *National Electrical Code, 1993.* Quincy, MA: National Fire Protection Association, 1992.

2. Taylor, Mark. *Residential Wiring.* Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1983.

Suggested Supplemental Resources

1. Software — *Electrical Wiring.* AAVIM, 745 Gaines School Road, Athens, GA 30605. Phone (800) 228-4689.

2. Book — Crost, Terrell, ed. *American Electrician's Handbook*, 11th ed. New York: McGraw-Hill, 1987.

Suggested Activities

Instructions for Evaluating Student Performance

Assignment Sheets—Be sure the student understands the criteria on which the evaluation is based. Assign a point value to each criterion and convert the total points to a percentage for grading.

Job Sheets—Be sure the student understands the criteria on which the evaluation is based. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in either the teacher edition or student manual. Then observe the student performing the procedure. Rate both process and product.

> Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily achieved the step(s) for each checkpoint area. If the student is unable to correctly complete the procedure, have the student review the materials and try again.
>
> Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria which have been provided as part of the job sheet. Complete the rating by assigning a point value to each criterion and by converting the point total to a percentage for grading. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) which best fits your program needs.

Option A

4 - Skilled—Can perform job with no additional training.
3 - Moderately skilled—Has performed job during training program; limited additional training may be required.
2 - Limited skill—Has performed job during training program; additional training is required to develop skill.
1 - Unskilled—Is familiar with process, but is unable to perform job.

Option B

Yes—Can perform job with no additional training.

No—Is unable to perform job satisfactorily.

Wiring Methods
Unit 11

Answers to Assignment Sheet 1

A. **350-2. Uses Not Permitted.** Flexible metal conduit shall not be used (1) in wet locations unless conductors are of lead-covered type or of other types approved for the specific conditions and the installation is such that water is not likely to enter other raceways or enclosures to which the conduit is connected; (2) in hoistways, other than provided in Section 620-21; (3) in storage-battery rooms; (4) in any hazardous (classified) location other than permitted in Sections 501-4(b) and 504-20; (5) where rubber-covered conductors are exposed to oil, gasoline, or other materials having a deteriorating effect on rubber; (6) underground or embedded in poured concrete or aggregate; or (7) where subject to physical damage.

B. **348-1. Use.** The use of electrical metallic tubing shall be permitted for both exposed and concealed work. Electrical metallic tubing shall not be used (1) where, during installation or afterward, it will be subject to severe physical damage; (2) where protected from corrosion solely by enamel; (3) in cinder concrete or cinder fill where subject to permanent moisture unless protected on all sides by a layer of noncinder concrete at least 2 inches (50.8 mm) thick or unless the tubing is at least 18 inches (457 mm) under the fill; (4) in any hazardous (classified) location except as permitted by Sections 502-4, 503-3, and 504-20; or (5) for the support of fixtures or other equipment. Where practicable, dissimilar metals in contact anywhere in the system shall be avoided to eliminate the possibility of galvanic action.

C. **346-1. Use.** The use of rigid metal conduit shall be permitted under all atmospheric conditions and occupancies subject to the following:

(a) Protected by Enamel. Ferrous raceways and fittings protected from corrosion solely by enamel shall be permitted only indoors and in occupancies not subject to severe corrosive influences.

(b) Dissimilar Metals. Where practicable, dissimilar metals in contact anywhere in the system shall be avoided to eliminate the possibility of glavanic action.

Exception: Aluminum fittings and enclosures shall be permitted to be used with steel rigid metal conduit, and steel fittings and enclosures shall be permitted to be used with aluminum rigid metal conduit.

(c) Corrosion Protection. Ferrous or nonferrous metal conduit, elbows, couplings, and fittings shall be permitted to be installed in concrete, in direct contact with the earth, or in areas subject to severe corrosive influences where protected by corrosion protection and judged suitable for the condition.

D. **351-4. Use.**

(a) Permitted. Liquidtight flexible metal conduit shall be permitted to be used in exposed or concealed locations:

(1) Where conditions of installation, operation, or maintenance require flexibility or protection from liquids, vapors, or solids.

(2) As permitted by Sections 501-4(b), 502-4, 503-3, and 504-20 and in other hazardous (classified) locations where specifically approved, and by Section 553-7(b).

(3) For direct burial where listed and marked for the purpose.

(b) Not Permitted. Liquidtight flexible metal conduit shall not be used:

(1) Where subject to physical damage.

(2) Where any combination of ambient and conductor temperature will produce an operating temperature in excess of that for which the material is approved.

E. **336-3. Uses Permitted.** Type NM and Type NMC cables shall be permitted to be used in one- and two-family dwellings, multifamily dwellings, and other structures, except as prohibited in Section 336-4. Where installed in cable trays, cables shall be identified for this use.

Answers to Assignment Sheet 1

F. **331-3. Uses Permitted.** The use of electrical nonmetallic tubing and fittings shall be permitted:

(1) In any building not exceeding three floors above grade.

a. For exposed work, where not subject to physical damage.

b. Concealed within walls, floors, and ceilings.

(2) In any building exceeding three floors above grade, electrical nonmetallic tubing shall be concealed within walls, floors, and ceilings where the walls, floors, and ceilings provide a thermal barrier of material that has at least a 15-minute finish rating as identified in listings of fire-rated assemblies.

(3) In locations subject to severe corrosive influences as covered in Section 300-6 and where subject to chemicals for which the materials are specifically approved.

(4) In concealed, dry, and damp locations not prohibited by Section 331-4.

(5) Above suspended ceilings where the suspended ceilings provide a thermal barrier of material that has at least a 15-minute finish rating as identified in listings of fire-rated assemblies, except as permitted in Section 331-3(1)a.

(6) Embedded in poured concrete, provided fittings identified for this purpose are used for connections.

(7) For wet locations indoors or in a concrete slab on or below grade, with fittings listed for the purpose.

331-4. Uses Not Permitted. Electrical nonmetallic tubing shall not be used:

(1) In hazardous (classified) locations.

Exception: Except as permitted by Section 504-20.

(2) For the support of fixtures and other equipment.

(3) Where subject to ambient temperatures exceeding those for which the tubing is listed.

(4) For conductors whose insulation temperature limitations would exceed those for which the tubing is listed.

(5) For direct earth burial.

G. **345-3. Uses Permitted.**

(a) All Atmospheric Conditions and Occupancies. Use of intermediate metal conduit shall be permitted under all atmospheric conditions and occupancies. Where practicable, dissimilar metals in contact anywhere in the system shall be avoided to eliminate the possibility of galvanic action. Intermediate metal conduit shall be permitted as an equipment grounding conductor.

Exception: Aluminum fittings and enclosures shall be permitted to be used with steel intermediate metal conduit.

(b) Corrosion Protection. Intermediate metal conduit, elbows, couplings, and fittings shall be permitted to be installed in concrete, in direct contact with the earth, or in areas subject to severe corrosive influences where protected by corrosion protection and judged suitable for the condition.

(c) Cinder Fill. Intermediate metal conduit shall be permitted to be installed in or under cinder fill where subject to permanent moisture where protected on all sides by a layer of noncinder concrete not less than 2 inches (50.8 mm) thich; where the conduit is not less than 18 inches (457 mm) under the fill; or where protected by corrosion protection and judged suitable for the condition.

H. **334-3. Uses Permitted.** Except where otherwise specified in this Code and where not subject to physical damage, Type MC cables shall be permitted as follows: (1) for services, feeders, and branch circuits; (2) for power, lighting, control, and signal circuits; (3) indoors or outdoors; (4) where exposed or concealed; (5) direct buried where identified for such use; (6) in cable tray; (7) in any approved raceway; (8) as open runs of cable; (9) as aerial cable on a messenger; (10) in hazardous (classified) locations as permitted in Articles 501, 502, 503, and 504; (11) in dry locations; and (12) in wet locations where any of the following conditions are met:

(1) The metallic covering is impervious to moisture.

(2) A lead sheath or moisture-impervious jacket is provided under the metal covering.

(3) The insulated conductors under the metallic covering are approved for use in wet locations.

Exception: See Section 501-4(b), Exception.

334-4. Uses Not Permitted. Type MC cable shall not be used where exposed to destructive corrosive conditions, such as direct burial in the earth, in concrete, or where exposed to cinder fills, strong chlorides, caustic alkalis, or vapors of chlorine or of hydrochloric acids.

Exception: Where the metallic sheath is suitable for the conditions or is protected by material suitable for the conditions.

Answers to Assignment Sheet 1

I. **324-3. Uses Permitted.** Concealed knob-and-tube wiring shall be permitted to be used only for extensions of existing installations and elsewhere only by special permission under the following conditions:

(1) In the hollow spaces of walls and ceilings.
(2) In unfinished attic and roof spaces as provided in Section 324-11.

324-4. Uses Not Permitted. Concealed knob-and-tube wiring shall not be used in commercial garages, theaters and similar locations, motion picture studios, hazardous (classified) locations, or in the hollow spaces of walls, ceilings, and attics where such spaces are insulated by loose, rolled, or foamed-in-place insulating material that envelops the conductors.

J. **352-1. Use.** The use of surface metal raceways shall be permitted in dry locations. They shall not be used (1) where subject to severe physical damage unless otherwise approved; (2) where the voltage is 300 volts or more between conductors unless the metal has a thickness of not less than .040 inch (1.02 mm); (3) where subject to corrosive vapors; (4) in hoistways; (5) in any hazardous (classified) location except Class I, Division 2 locations as permitted in the exception to Section 501-4(b); nor (6) concealed except as follows:

Exception No. 1: Surface metal raceways shall be permitted for underplaster extensions where identified for such use.

Exception No. 2: As permitted in Section 645-5(d)(2).

Wiring Methods
Unit 11

Answers to Written Test

1. a. 4
   b. 5
   c. 2
   d. 1
   e. 3

2. a. Nonmetallic-sheathed cable (Romex)
   b. Concealed knob-and-tube wiring
   c. Rigid metal conduit
   d. Electrical metallic tubing (EMT)
   e. Flexible metal conduit
   f. Liquidtight flexible metal conduit
   g. Surface raceways
   h. Low voltage
   i. PVC fittings and connections
   j. Intermediate metal conduit
   k. Metal clad cable
   l. Electrical nonmetallic tubing

3. a. 3
   b. 5
   c. 6
   d. 2
   e. 8
   f. 1
   g. 7
   h. 4
   i. 9
   j. 10

Wiring Methods
Unit 11

Written Test

Name ____ Score ________________

1. Match terms related to wiring methods with their correct definitions. Write the correct numbers in the blanks.

______a. That interior and exterior wiring, including power, lighting, control, and signal circuit wiring, together with all of its associated hardware, fittings, both permanently and temporarily installed, which extends from the load end of the service drop, or load end of the service lateral conductors to the outlet(s); such wiring does not include wiring internal to appliances, fixtures, motors, controllers, motor control centers, and similar equipment

______b. An accessory, such as a locknut, bushing, or other part of a wiring system, that is intended primarily to perform a mechanical rather than an electrical function

______c. A general term including material, fittings, devices, appliances, fixtures, and apparatus used as a part of, or in connection with, an electrical installation

______d. On or attached to the surface, or behind panels designed to allow access

______e. A factory assembly of two or more insulated conductors having an outer sheath of moisture-resistant, flame-retardant, nonmetallic material

1. Exposed

2. Equipment

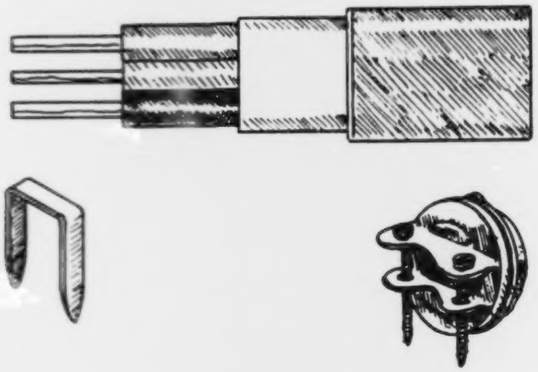
3. Cable

4. Premises wiring

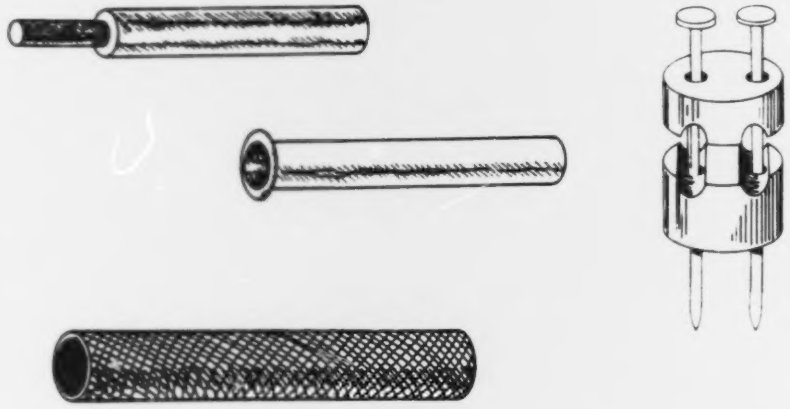
5. Fitting

Written Test

2. Identify the following wiring methods found in electrical trades. Write the correct names in the blanks.

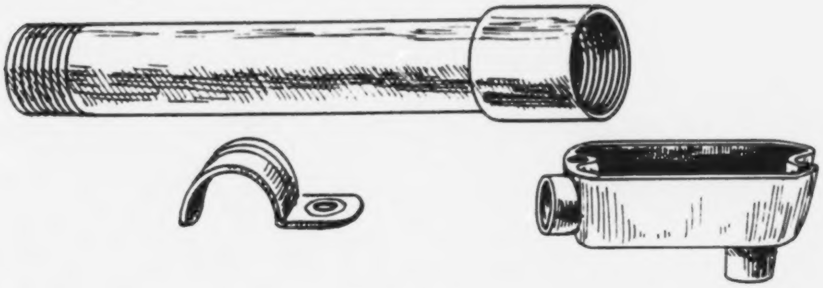


a. ______________________________

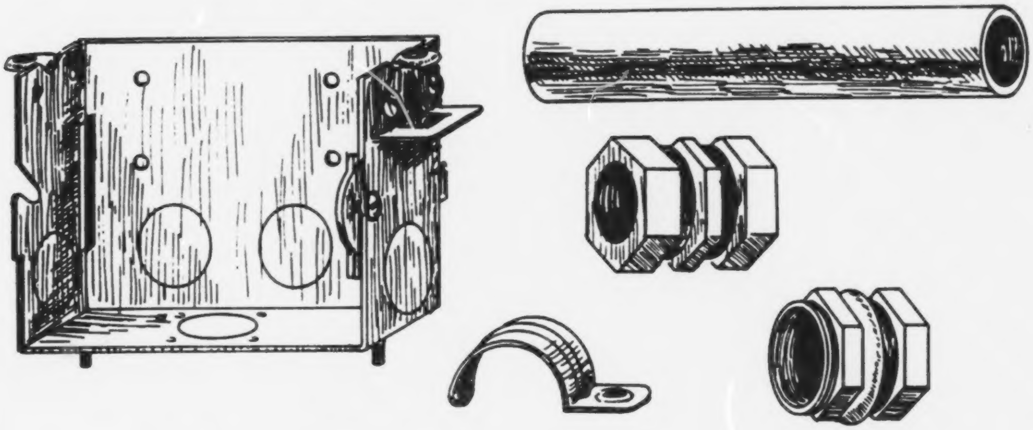


b. ______________________________

Written Test

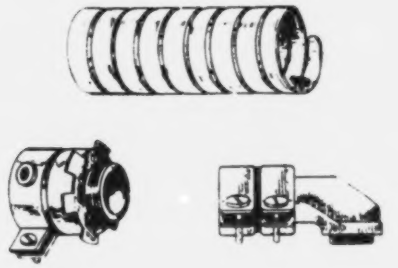


c. ____

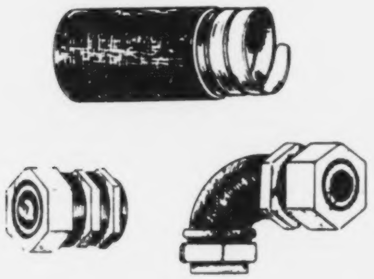


d. ____

Written Test

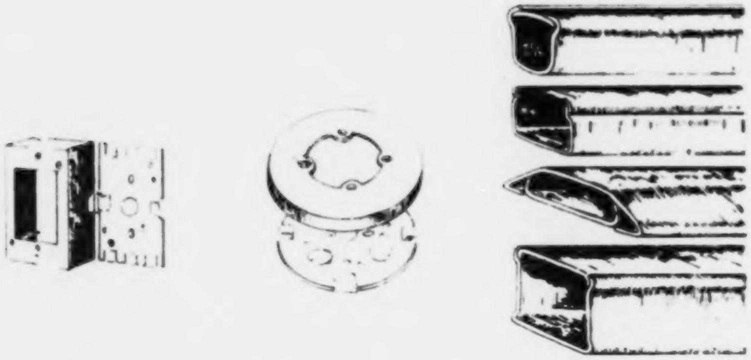


e. ____

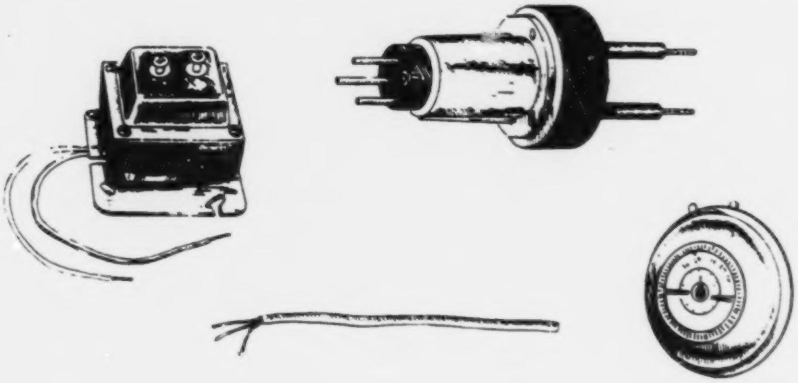


f. ____

Written Test

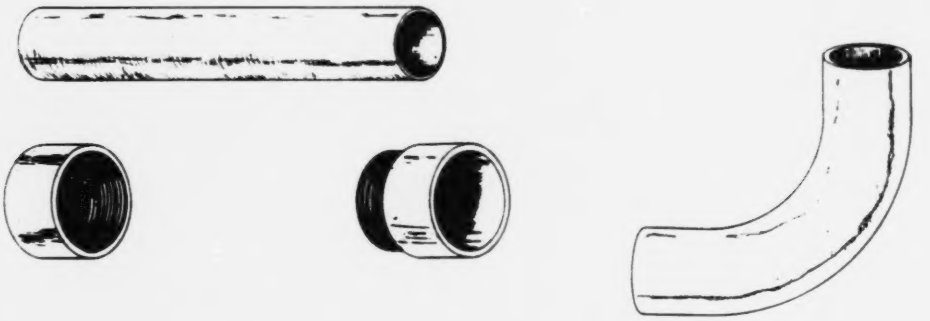


g. ____

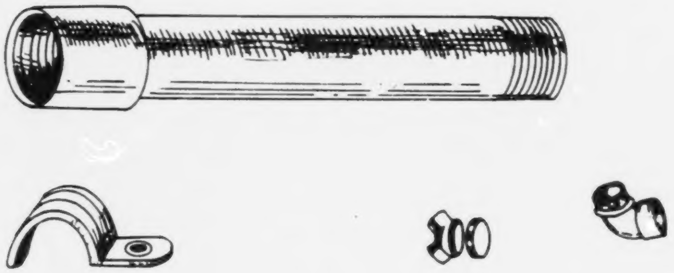


h. ____

Written Test

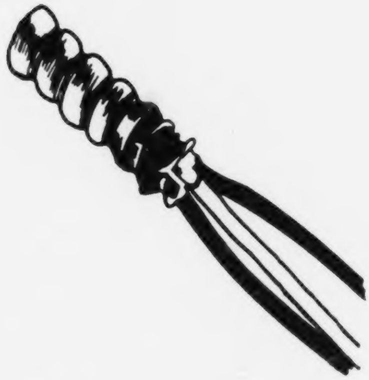


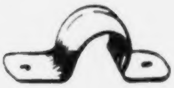
i. ______________________________

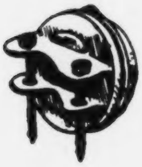


j. ______________________________

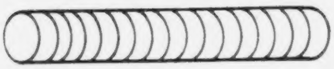
Written Test

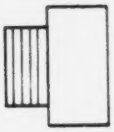


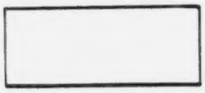




k. ____________________







l. ____________________

Written Test

3. Match wiring methods with their common applications. Write the correct numbers in the blanks. Applications are continued on the next page.

______a. Nonmetallic sheathed cable: general residential rough-in and circuit extensions in existing dwellings; underground feeder and branch circuit cable (UF): direct burial for yard lights or extensions

______b. Extensions of existing installations, elsewhere by special permission

______c. Through-eave service masts; underground circuit extension; in concrete walls, floors, or ceilings; underground service riser; commercial and industrial locations; hazardous locations

______d. Service raceway, protecting grounding electrode conductor, commercial and industrial locations

______e. Connecting recessed lighting fixtures, enclosing motor leads

______f. Connecting air conditioning condensers to disconnects, enclosing motor leads needing protection from liquids and vapors

______g. Interior circuit extensions where concealed work is not necessary or not possible, on interior concrete surfaces

______h. Chime circuits, intercom wiring, thermostat circuits, lighting control

______i. Locations subject to severe corrosive influences; suspended ceilings; concealed within walls, floors, and ceilings

______j. Services; feeders; branch circuits; power, lighting, and signal circuits

______k. Lighter weight and thinner wall than ridge, all atmospheric conditions, hazardous locations, underground circuits

1. Liquidtight flexible metal conduit
2. Electrical metallic tubing
3. Cable
4. Low voltage
5. Concealed knob-and-tube wiring
6. Rigid metal conduit
7. Surface raceways
8. Flexible metal conduit
9. Electrical nonmetallic tubing
10. Intermediate metal conduit
11. Metal-clad cable

*Permission to duplicate this test is granted.

Wiring Methods
Unit 11

Unit Evaluation Form

Student Name ______________________________ Unit Rating __________

Assignment Sheet 1—Reference the *National Electrical Code* to Identify Uses of Wiring Methods Rating _____

Comments: ____

____

Job Sheet 1—Install a Set-Screw Conduit Fitting Rating _____

Comments: ____

____

Job Sheet 2—Install a Compression-Type Conduit Fitting Rating _____

Comments: ____

____

Job Sheet 3—Braid the Ground Conductor of a Service Entrance Cable Rating _____

Comments: ____

____

Job Sheet 4—Install an ENT Coupling and Connector on ENT Conduit Rating _____

Comments: ____

____

Written Test Scores

Pretest _____ Posttest _____ Other _____

Other ____

____

Teacher Signature ______________________________ Date __________

Student Signature ______________________________ Date __________

***Permission to duplicate this form is granted.**

Wiring Methods
Unit 11

Information Sheet

1. **Terms and definitions**

   a. **Cable** — A factory assembly of two or more insulated conductors having an outer sheath of moisture-resistant, flame-retardant, nonmetallic material

   b. **Equipment** — A general term including material, fittings, devices, appliances, fixtures, and apparatus, used as a part of, or in connection with, an electrical installation

   c. **Exposed** (as applied to wiring methods) — On or attached to the surface, or behind panels designed to allow access

   d. **Fitting** — An accessory, such as a locknut, bushing, or other part of a wiring system, that is intended primarily to perform a mechanical rather than an electrical function

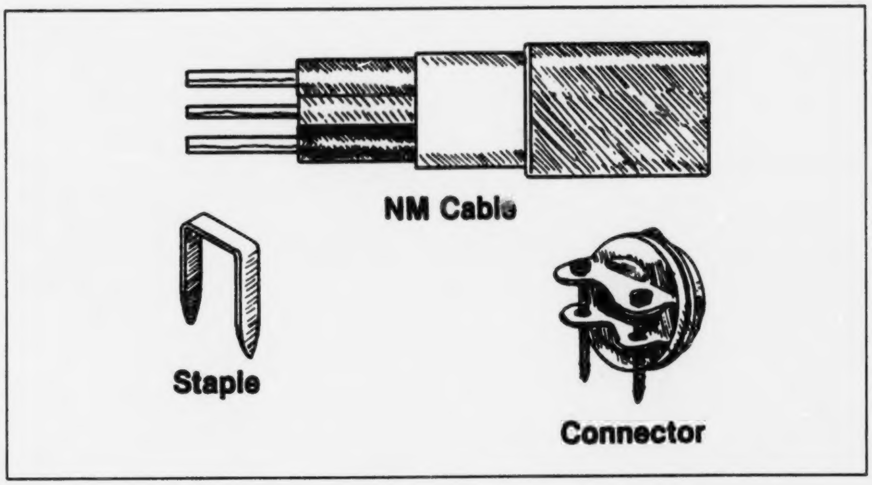
   e. **Premises wiring (system)** — That interior and exterior wiring, including power, lighting, control, and signal circuit wiring, together with all of its associated hardware, fittings, both permanently and temporarily installed, which extends from the load end of the service drop, or load end of the service lateral conductors to the outlet(s); such wiring does not include wiring internal to appliances, fixtures, motors, controllers, motor control centers, and similar equipment

Information Sheet

2. **Wiring methods found in electrical trades** (Figures 1-12)

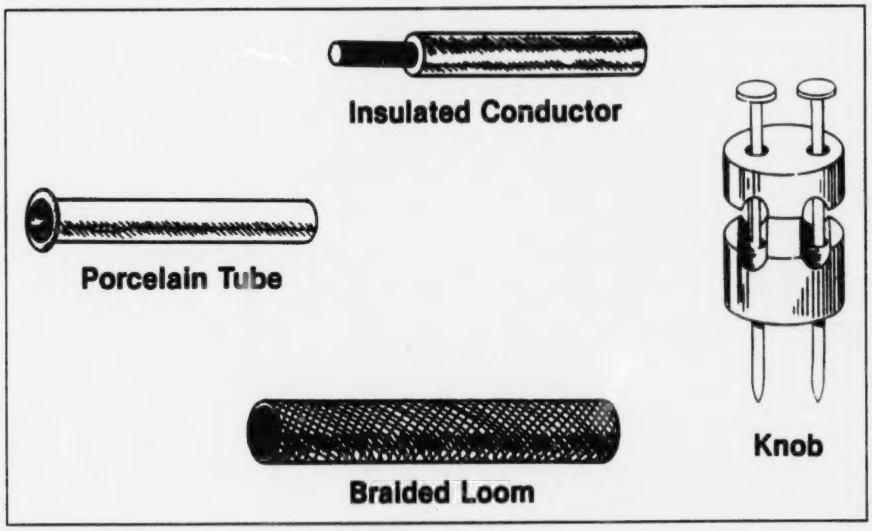
   a. Nonmetallic sheathed cable (Romex)

Figure 1


NM Cable
Staple
Connector

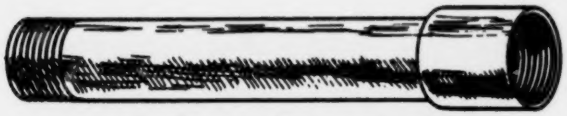
   b. Concealed knob-and-tube wiring

Figure 2

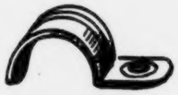

Insulated Conductor
Porcelain Tube
Knob
Braided Loom

c. Rigid metal conduit

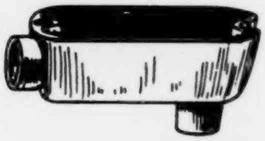
Figure 3



Metal Conduit and Coupling



One-Hole Strap

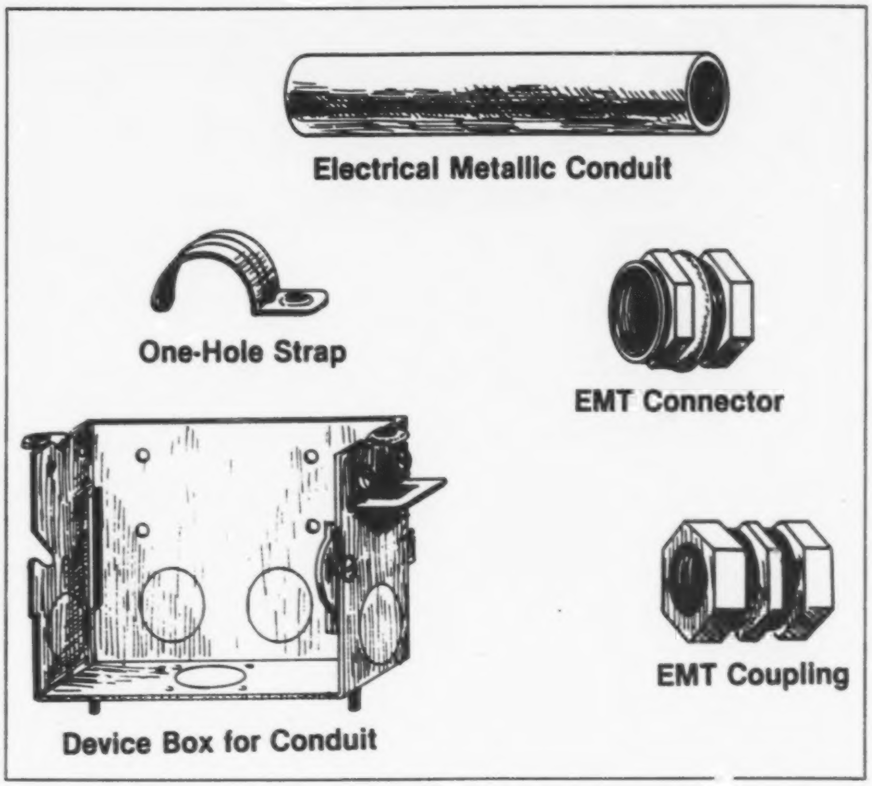


Conduit Body

Information Sheet

d. Electrical metallic tubing (EMT)

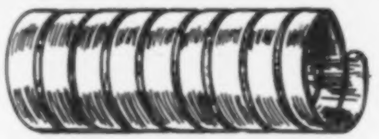
Figure 4


Electrical Metallic Conduit
One-Hole Strap
EMT Connector
EMT Coupling
Device Box for Conduit

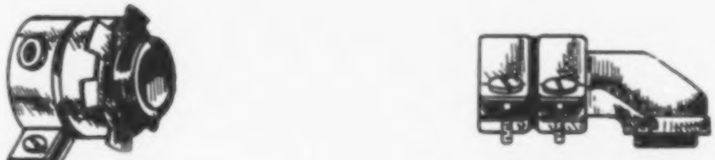
Information Sheet

e. Flexible metal conduit

Figure 5



Flexible Metal Conduit



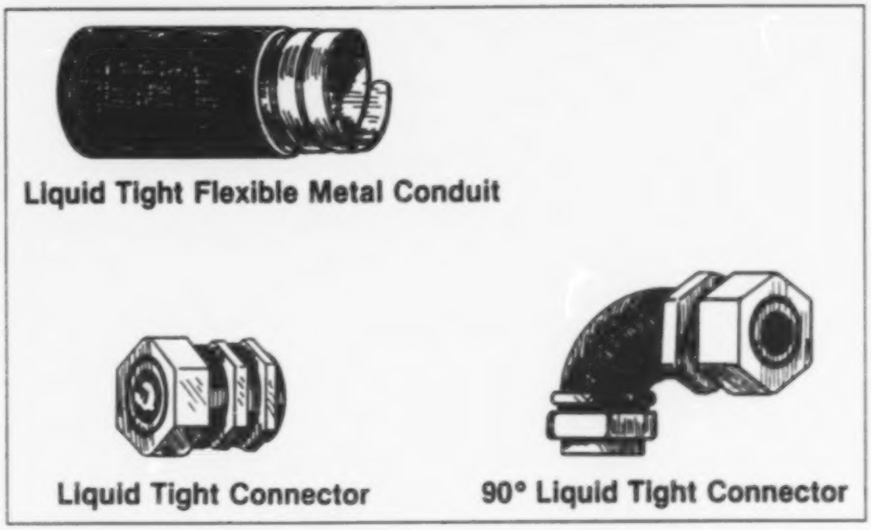
Straight Connector

90° Connector

Information Sheet

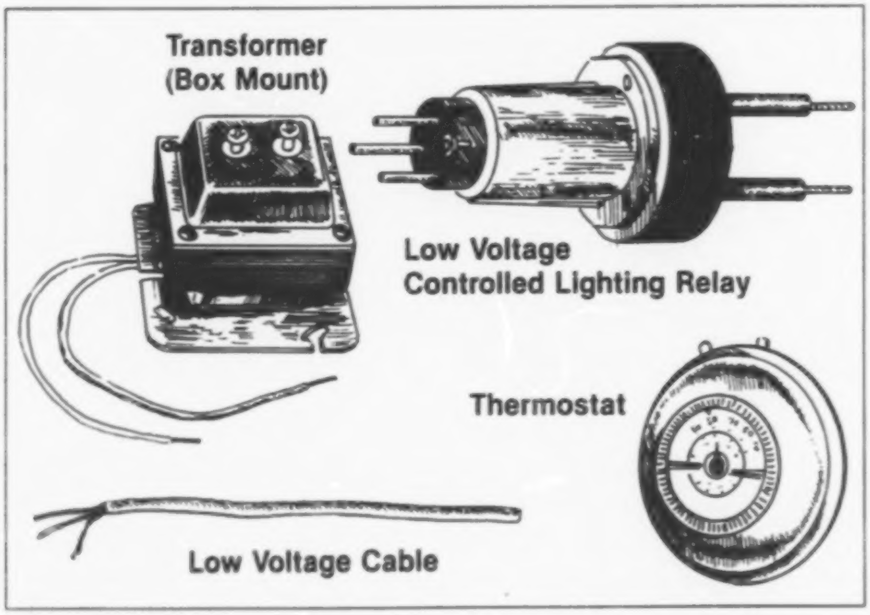
f. Liquid tight flexible metal conduit

Figure 6


Liquid Tight Flexible Metal Conduit
Liquid Tight Connector
90° Liquid Tight Connector

g. Low voltage devices

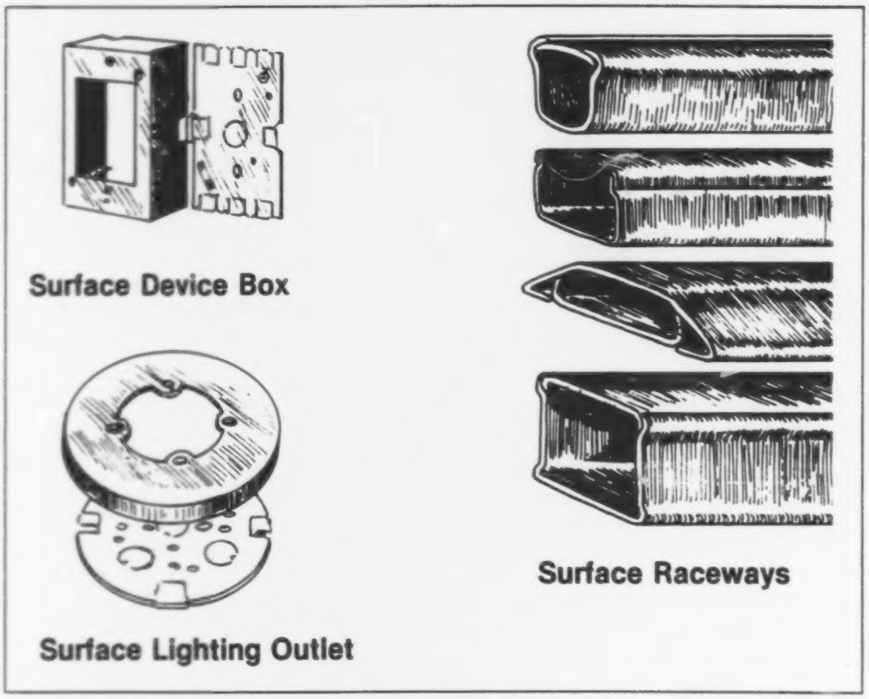
Figure 7


Transformer (Box Mount)
Low Voltage Controlled Lighting Relay
Thermostat
Low Voltage Cable

Information Sheet

h. Surface raceways and boxes

Figure 8



Surface Device Box

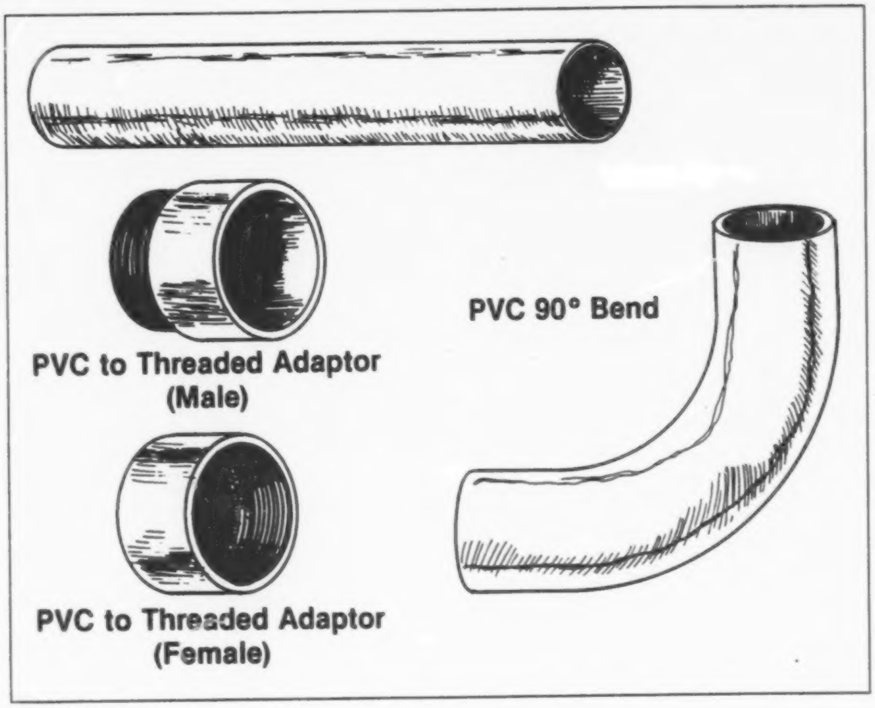
Surface Lighting Outlet

Surface Raceways

Information Sheet

i. PVC fittings and connections

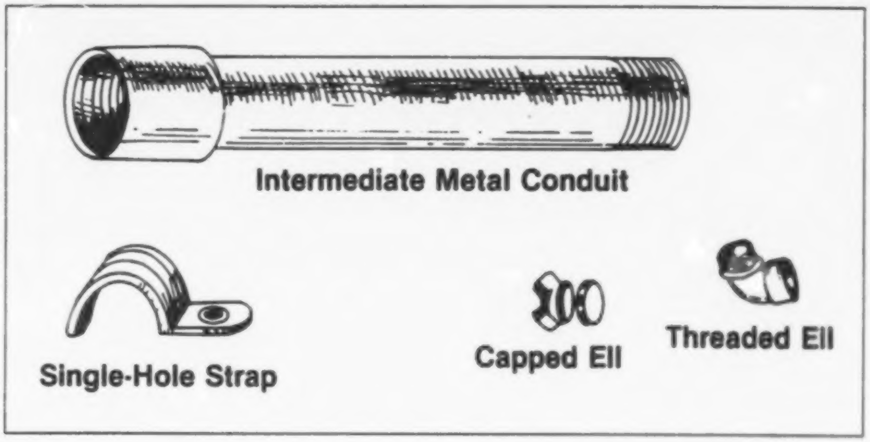
Figure 9


PVC 90° Bend
PVC to Threaded Adaptor (Male)
PVC to Threaded Adaptor (Female)

Information Sheet

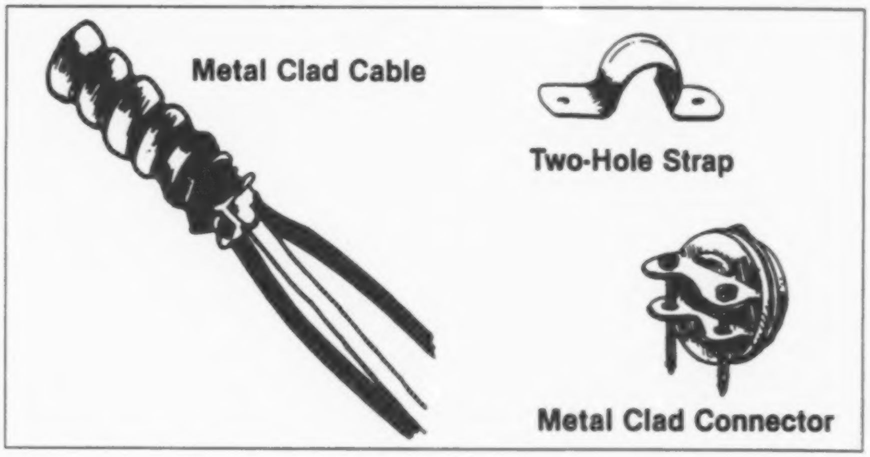
j. Intermediate metal conduit

Figure 10


Intermediate Metal Conduit
Single-Hole Strap
Capped Ell
Threaded Ell

k. Metal clad cable

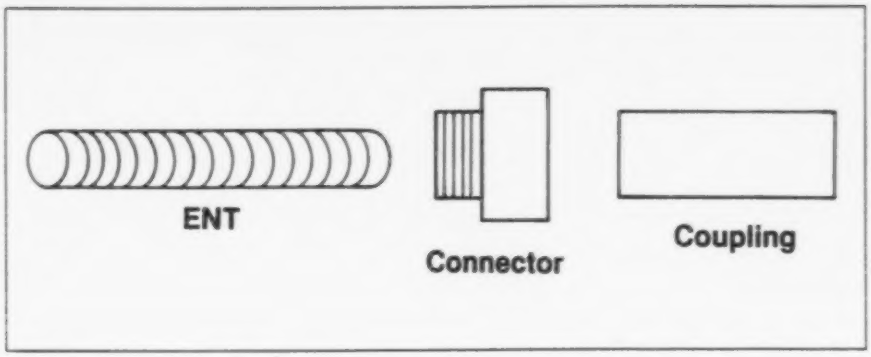
Figure 11


Metal Clad Cable
Two-Hole Strap
Metal Clad Connector

Information Sheet

I. Electrical nonmetallic tubing (ENT)

Figure 12



3. Wiring methods and their common applications

a. Cable

- Nonmetallic-sheathed cable (*NEC* Art: 336)
  - General residential rough-in
  - Circuit extensions in existing dwellings

  Note: Nearly all the premises wiring in most new residential homes is done with Type NM and NMC cable.

- Underground feeder and branch circuit cable (UF)—Direct burial for yard lights or extensions

b. Concealed knob-and-tube wiring (*NEC* Art: 324)

- Extensions of existing installations
- Elsewhere by special permission

c. Rigid metal conduit (*NEC* Art: 346)

- Through-eave service masts
- Underground circuit extension
- In concrete wall, floors, or ceilings

Note: Wiring in poured basement walls, ceilings, and floors is usually done with rigid metal conduit.

Information Sheet

- Underground service riser
- Commercial and industrial locations
- Hazardous locations

d. Electrical metallic tubing (*NEC* Art: 348)

- Service raceway

  Note: EMT is not suitable for through-eave installations.
- Protecting grounding electrode conductor
- Commercial and industrial locations

e. Flexible metal conduit (*NEC* Art: 350)

- Connecting recessed lighting fixtures
- Enclosing motor leads

f. Liquid tight flexible metal conduit (*NEC* Art: 351)

- Connecting air conditioning condensers to disconnects
- Enclosing motor leads needing protection from liquids and vapors

g. Surface raceways (*NEC* Art: 352)

- Interior circuit extensions where concealed work is not necessary or not possible
- On interior concrete surfaces

h. Low voltage (*NEC* Art: 725)

- Chime circuits
- Intercom wiring
- Thermostat circuits
- Lighting control

Information Sheet

i. Electrical nonmetallic tubing (*NEC* Art: 331)
   - Locations subject to severe corrosive influences
   - Suspended ceilings
   - Concealed within walls, floors, and ceilings

j. Intermediate metal conduit (*NEC* Art: 345)
   - Lighter weight and a thinner wall than ridge
   - May be used in all atmospheric conditions
   - Hazardous locations
   - Underground circuits

k. Metal-clad cable (*NEC* Art: 334)
   - Services
   - Feeders
   - Branch circuits
   - Power, lighting, and signal circuits

Wiring Methods
Unit 11

Assignment Sheet 1—Reference the *National Electrical Code* to Identify Uses of Wiring Methods

Name ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
All ten methods referenced	______
Ten of ten use descriptions accurate per assignment sheet answers	______
Ten of ten *Code* locations accurate per assignment sheet answers	______

Directions: Using the *National Electrical Code*, list the permitted and not permitted uses for the following wiring methods and the specific locations where they are found in the *Code*.

A. Flexible metal conduit: ______________________________

B. Electrical metallic tubing: ______________________________

Assignment Sheet 1

C. Rigid metal conduit: ______

D. Liquidtight flexible metal conduit: ______

E. Nonmetallic-sheathed cable: ______

Assignment Sheet 1

F. Electrical nonmetallic tubing: ______

G. Intermediate metal conduit: ______

H. Metal-clad cable: ______

Assignment Sheet 1

I. Concealed knob-and-tube wiring: ______

J. Surface raceways: ______

Wiring Methods
Unit 11

Job Sheet 1—Install a Set-Screw Conduit Fitting

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation criteria	**Rating**
Gathered and used appropriate equipment and materials	______
Performed procedure safely	______
Performed all steps in correct sequence	______
Cleaned work area	______

A. Equipment and materials

½-inch set-screw fitting, either a connector or coupling
½-inch conduit
Screwdriver
Safety glasses

B. Procedure

☐ 1. Put on safety glasses.

☐ 2. Gather equipment and materials.

☐ 3. Check conduit to see if it is reamed and has a square-cut end.

☐ 4. Pick up connector.

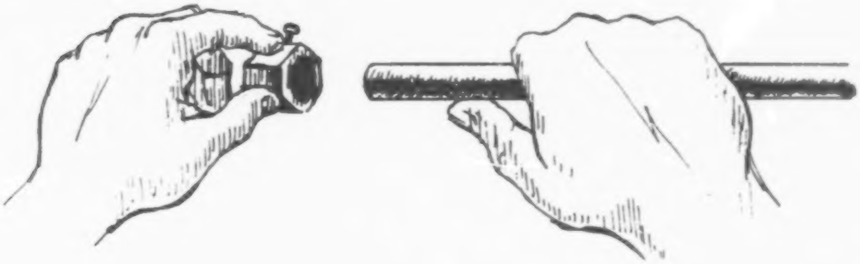
Note: Hold the connector in the most skillful of your hands. For example, a right-handed person should hold it in the right hand.

☐ 5. Pick up conduit with other hand.

Job Sheet 1

☐ 6. Slide connector onto conduit until it bottoms. (Figure 1)

Figure 1

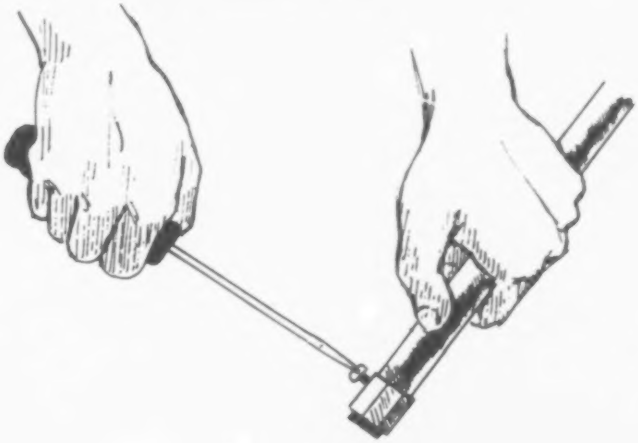


☐ 7. Secure screw with screwdriver. (Figure 2)

Caution: Keep hand holding conduit in position away from the connector to avoid getting jabbed if the screwdriver should slip. Do not overtighten the set screw.

Note: During this operation the least skillful of your hands should be involved only in the holding of the conduit after Step 4. This nonshifting approach should save time by saving hand movement.

Figure 2



Job Sheet 1

☐ 8. Clean work area, and return equipment and materials to proper storage.

Evaluator's comments: ______________________________

____

____

Wiring Methods
Unit 11

Job Sheet 2—Install a Compression-Type Conduit Fitting

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation criteria	**Rating**
Gathered and used appropriate equipment and materials	______
Performed procedure safely	______
Performed all steps in correct sequence	______
Cleaned work area	______

A. Equipment and materials

½-inch compression-type fitting, either a connector or coupling
½-inch conduit
Two pairs groove-joint pliers or two adjustable wrenches, or one wrench and one pair of pliers
Safety glasses

B. Procedure

☐ 1. Put on safety glasses.

☐ 2. Gather equipment and materials.

☐ 3. Check conduit to see if it is reamed and has straight even ends.

☐ 4. Pick up connector.

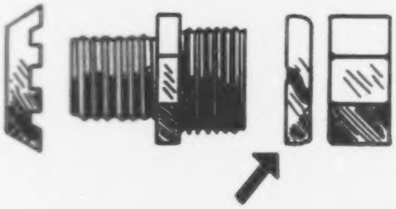
Note: Hold the connector in the least skillful hand, and use the most skillful hand for the next two operations to avoid handshifting.

Job Sheet 1

☐ 5. Loosen compression nut.

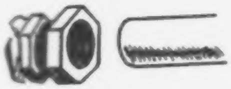
Note: Do not completely remove the nut. Look inside to ensure that the compression ring is inside the fitting. See Figure 1.

Figure 1



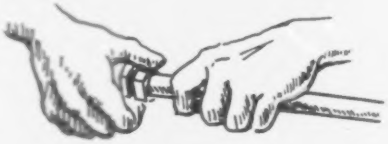
☐ 6. Slide fitting onto conduit. (Figure 2)

Figure 2



☐ 7. Tighten compression nut by hand. (Figure 3)

Figure 3

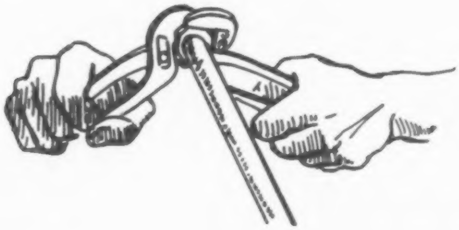


Job Sheet 2

☐ 8. Tighten fitting with pliers or adjustable wrenches. (Figure 4)

Caution: Overtightening the smaller trade-size fittings can cause threads to strip or nuts to crack.

Figure 4



☐ 9. Clean work area, and return equipment and materials to proper storage.

Evaluator's comments: ______________________________

____

____

Wiring Methods
Unit 11

Job Sheet 3—Braid the Ground Conductor of a Service Entrance Cable

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
Gathered and used appropriate equipment and materials	______
Performed procedure safely	______
Performed all steps in correct sequence	______
Cleaned work area	______

A. Equipment and materials

SE cable
Knife
Safety glasses
Lineman's pliers

B. Procedure

☐ 1. Put on safety glasses.

☐ 2. Gather equipment and materials.

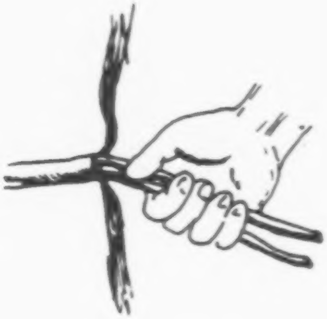
☐ 3. Strip off a length of the outer sheath.

Note: Always use safe work practices when using a knife.

Job Sheet 3

☐ 4. Separate ground strands into two separate groups. (Figure 1)

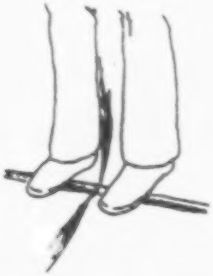
Figure 1



☐ 5. Stand on cable. (Figure 2)

Note: Be sure that the conductors are not on rocks or other materials that could damage the insulation while you have them secured.

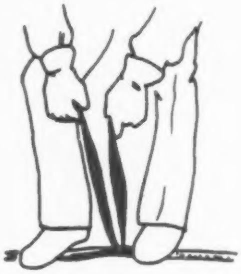
Figure 2



Job Sheet 3

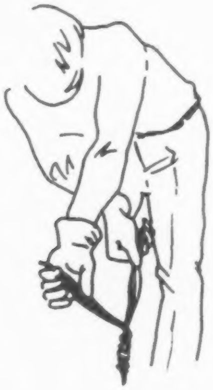
☐ 6. Bend over and grasp the separated neutral. (Figure 3)

Figure 3



☐ 7. Twist the conductor together while pulling upward. (Figure 4)

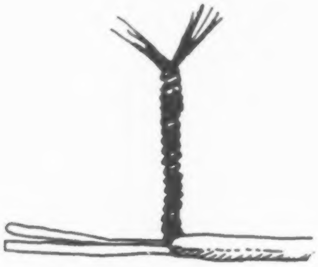
Figure 4



Job Sheet 3

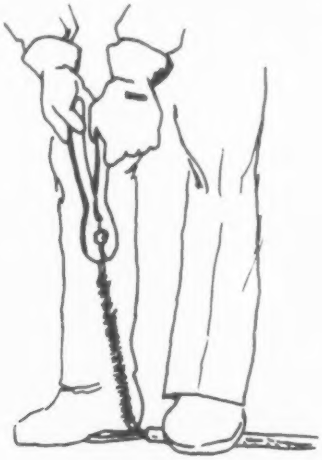
☐ 8. Braid as far as possible by hand. (Figure 5)

Figure 5



☐ 9. Twist with pliers until braid is continuous and uniform. (Figure 6)

Figure 6



Note: Have instructor evaluate your work.

☐ 10. Clean work area, and return equipment and materials to proper storage.

Evaluator's comments: ______________________________

____

____

Wiring Methods
Unit 11

Job Sheet 4—Install an ENT Coupling and Connector on ENT Conduit

Name ________________ Attempt Number ________

Date ________________ Overall Rating ________

Evaluation criteria	**Rating**
Gathered and used appropriate equipment and materials	______
Performed procedure safely	______
Performed all steps in correct sequence	______
Cleaned work area	______

A. Equipment and materials

1- × ½-inch ENT conduit
½-inch ENT connector
½-inch ENT coupling
One can PVC glue
Hook knife

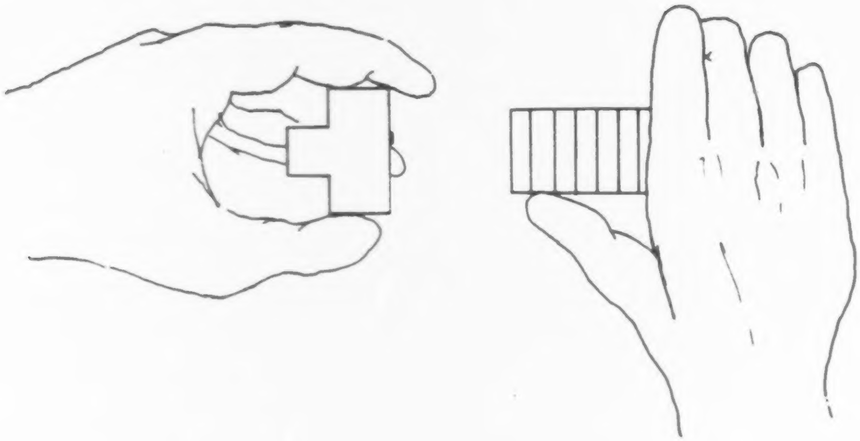
Job Sheet 4

B. Procedure

☐ 1. Clean ENT conduit.

☐ 2. Apply PVC on end of ENT. (Figure 1)

Figure 1



☐ 3. Push ENT conduit into connector.

☐ 4. Hold tightly until PVC glue dries.

☐ 5. Repeat process for coupling.

Note: Have instructor evaluate your work.

☐ 6. Clean work area, and return equipment and materials to proper storage.

Evaluator's comments: ______________________________

____

____

Conductors
Unit 12

Objective Sheet

Unit Objective

After completing this unit, the student should be able to select and install proper conductors. The student should demonstrate these competencies by completing the assignment and job sheets and scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to conductors with their correct definitions.
2. List factors that determine conductor type and size.
3. Select from a list characteristics of good connections.
4. Identify types of connectors, terminals, and lugs.
5. Identify types of insulation, given its characteristics, applications, and code letters.
6. List three conductors commonly found in electrical wiring.
7. Match with their uses types of cables found in the electrical field.
8. Select true statements about cords and their conductors.
9. Complete statements about cables and their conductors.
10. Select conductors for various ampacities and temperatures. (Assignment Sheet 1)
11. Calculate ampacity of conductors, given number of conductors in raceway. (Assignment Sheet 2)
12. Calculate ampacity and conductor sizes for specific types of loads. (Assignment Sheet 3)
13. Select cords for various applications. (Assignment Sheet 4)
14. Select proper types of insulation. (Assignment Sheet 5)

Objective Sheet

15. Install cord on utilization equipment. (Job Sheet 1)
16. Use a fish tape to install wire in conduit. (Job Sheet 2)
17. Prepare an aluminum conductor for termination. (Job Sheet 3)

Conductors
Unit 12

Suggested Activities

Instructional Plan

Preparation

1. Read the unit carefully and plan for instruction. Study the specific objectives to determine the order in which you will present them.

2. Review Teaching Suggestions section that follows. Plan for classroom activities.

3. Plan your presentation to take advantage of student learning styles and to accommodate special needs students.

4. Make transparency from the transparency master included with this unit. This appears in the teacher edition only and is designed to be used with the following objective:

   TM 1—AWG Conductor Sizes (Objective 2)

5. Obtain films, videotapes, and other resources to supplement instruction of this unit.

6. Develop teaching plan. Adjust for different learning styles.

7. Make copies of Unit Evaluation Form.

Delivery and Application

8. Provide students with unit of instruction.

9. Discuss unit and specific objectives.

10. Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.

11. Discuss the assignment sheets and schedule due dates. Review criteria for evaluation of these activities.

12. Discuss and demonstrate the job sheets. Review criteria for evaluation of these activities. Schedule performance dates.

Suggested Activities

Evaluation

13. Discuss the use of the Unit Evaluation Form with students. Discuss the rating scale that will be used for student evaluation.

14. Make copies of the written test. Add or modify test items as needed.

15. Give written test.

16. Compile assignment and job sheet ratings and written test scores on the Unit Evaluation Form. Add any additional assignments or supplemental activities that should be part of the unit evaluation.

17. Reteach and retest as required.

Teaching Suggestions

Note: Skill areas appearing in boldface type in the Teaching Suggestions refer to the academic and workplace skills identified by the American Society for Training and Development (ASTD) and the U.S. Department of Labor. These have been adapted by MAVCC.

1. Construct a display of conductors, showing types and sizes.

2. Construct a display of cords and cables, showing types and sizes.

3. Invite a local supplier to demonstrate termination methods. Skill areas: **Listening, observing application of scientific principles**

Resources Used in Developing This Unit

1. Clidera, Robert and Kenneth Sharpe. *Construction Wiring*. Albany, NY: Delmar Publishers.

2. Earley, Mark W., John M. Caloggero, and Richard H. Murray. *National Electrical Code 1993*. Quincy, MA: National Fire Protection Association, 1992.

3. Taylor, Mark. *Residential Wiring*. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1983.

4. Teague, Cash and Garner Pewewardy. *Industrial Electricity: In-Plant Distribution*. Stillwater, OK: Oklahoma Curriculum and Instructional Materials Center, 1984.

Suggested Activities

Instructions for Evaluating Student Performance

Assignment Sheets—Be sure the student understands the criteria on which the evaluation is based. Assign a point value to each criterion and convert the total points to a percentage for grading.

Job Sheets—Be sure the student understands the criteria on which the evaluation is based. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in either the teacher edition or student manual. Then observe the student performing the procedure. Rate both process and product.

> Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily achieved the step(s) for each checkpoint area. If the student is unable to correctly complete the procedure, have the student review the materials and try again.
>
> Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria which have been provided as part of the job sheet. Complete the rating by assigning a point value to each criterion and by converting the point total to a percentage for grading. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) which best fits your program needs.

Option A

4 - Skilled—Can perform job with no additional training.
3 - Moderately skilled—Has performed job during training program; limited additional training may be required.
2 - Limited skill—Has performed job during training program; additional training is required to develop skill.
1 - Unskilled—Is familiar with process, but is unable to perform job.

Option B

Yes—Can perform job with no additional training.

No—Is unable to perform job satisfactorily.

Conductors
Unit 12

Answers to Assignment Sheets

Assignment Sheet 1

A. #12 AWG
B. #8 AWG
C. #10 AWG
D. #3 AWG
E. #2 AWG
F. #250 MCM
G. #500 MCM
H. #1750 MCM
I. #4 AWG
J. #4 AWG
K. #000 AWG

Assignment Sheet 2

A. 50 amperes
B. 35 amperes
C. 85 amperes
D. 175 amperes
E. 255 amperes
F. 100 amperes
G. 40 amperes
H. 21 amperes
I. 59.5 amperes
J. 122.5 amperes
K. 178.5 amperes
L. 70 amperes

Assignment Sheet 3

Part 1

A. 33.75, #8 AWG
B. 81.25, #3 AWG
C. 90, #3 AWG

Part 2

A. 140%, #6 AWG
B. 150%, I/O
C. 85%, #3 AWG
D. 120%, #2 AWG
E. 150%, #10 AWG

Answers to Assignment Sheets

Assignment Sheet 4

	Type	Size
A.	SJEO, SJO, SJOO, SJTO, SJTOO	#8 AWG
B.	DP	#12 AWG
C.	SE, SEO, SJ	#4 AWG
D.	E, EO	#12 AWG

Assignment Sheet 5

Part 1

A. MTW, THW, THWN
B. MTW
C. T, TW, THHN, THW, THWN
D. TW, MTW, THW, THWN
E. THHN, MTW, THW, THWN

Part 2

A. 250°C, 482°F
B. 60°C, 140°F
C. 75°C, 167°F
D. 90°C, 194°F
E. 60°C, 140°F
F. 90°C, 194°F
G. 75°C, 167°F
H. 90°C, 194°F
I. 150°C, 302°F
J. 75°C, 167°F
K. 125°C, 257°F
L. 90°C, 194°F
M. 75°C, 167°F
N. 90°C, 194°F
O. 75°C, 167°F

Conductors
Unit 12

Answers to Written Test

1.	a.	1	f.	10	k.	11	p.	17
	b.	6	g.	9	l.	16	q.	13
	c.	7	h.	2	m.	15		
	d.	4	i.	3	n.	14		
	e.	5	j.	8	o.	12		

2. a. Full load amperes
   b. Number of conductors
   c. Type of load served
   d. Length of run
   e. Ambient temperature
   f. Voltage

3. a, b, d, f, i

4. a. Crimp sleeve connector
   b. Single terminal
   c. Ring lugs
   d. Set-screw lug
   e. Crimp-type butt connectors
   f. Split bolt lug
   g. Twin or double terminal
   h. Spade connectors
   i. Wire nut lugs
   j. Service entrance lug
   k. Quick disconnect connector

5. a. Moisture-resistant thermoplastic
   b. Heat-resistant thermoplastic
   c. Moisture- and heat-resistant thermoplastic
   d. Moisture-, heat-, and oil-resistant thermoplastic
   e. Moisture- and heat-resistant thermoplastic
   f. Moisture- and heat-resistant thermoplastic

6. a. Copper
   b. Aluminum
   c. Copper-clad aluminum

7.	a.	2	d.	5
	b.	1	e.	4
	c.	6	f.	3

Answers to Written Test

8. a, d

9. a. Identified
   b. Green
   c. Ungrounded
   d. Amp, condition

Conductors
Unit 12

Written Test

Name ______________________________ Score ______________

1. Match terms related to conductors with their correct definitions. Write the correct numbers in the blanks. Definitions are continued on the next page.

______a. Conductor made of aluminum

______b. The diameter of a conductor in thousandths of inches multiplied times itself

______c. Assigning colors to conductors based on their uses

______d. A conductor having no covering or electrical insulation

______e. A factory assembly of two or more insulated conductors having an outer sheath of moisture-resistant, flame-retardant nonmetallic material

______f. Two- (or more) stranded conductors grouped together in a flexible covering

______g. Conductor made of copper

______h. The current, in amperes, that a conductor can carry continuously under the conditions of use without exceeding its temperature rating

______i. A series of specified diameters and thicknesses established as a standard in the United States; also known as Brown and Sharp gauge (B and S gauge)

______j. Aluminum conductor with an outer coating of copper metallurgically bonded to the aluminum core

1. Aluminum wire
2. Ampacity
3. American wire gauge (AWG)
4. Base conductor
5. Cable
6. Circular mils
7. Color coding
8. Copper-clad aluminum
9. Copper wire
10. Cord
11. Covered
12. Fish tape
13. Grounded conductor
14. Insulated
15. Mil
16. Type letter
17. Grounding conductor

Written Test

______k. Conductor encased within material of composition and thickness not recognized by the *NEC* as electrical insulation

______l. Identification accepted by the trade in referring to the particular types of insulation

______m. One thousandth of an inch

______n. Conductor encased within material of composition and thickness recognized by the *NEC* as electrical insulation

______o. Long tape of steel, nylon, or other material used to push or pull a conductor into a raceway

______p. Conductors used to connect equipment or the grounded circuit of a wiring system to a grounding electrode or electrodes

______q. A system or circuit conductor that is intentionally grounded (connected to the earth or some conductor that serves in place of the earth)

2. List six factors that determine type and size of conductors.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

f. ______________________________

Written Test

3. Select from the following list characteristics of good connections. Write an "X" in the blank before each correct characteristic.

    ______a. Use approved devices and oxidation inhibitors when connected copper to aluminum

    ______b. Provide full contact

    ______c. Are made with magnetic screwdriver

    ______d. Are tight

    ______e. Require no tools for installation

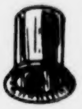
    ______f. Are clean

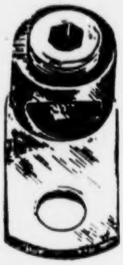
    ______g. Provide quick disconnect

    ______h. Show bright terminal connection

    ______i. Are strong

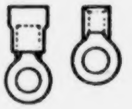
4. Identify the following types of connectors, terminals, and lugs. Write the correct names in the blanks.



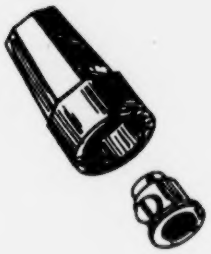


a. ______________________ b. ______________________

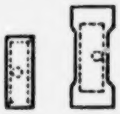
Written Test



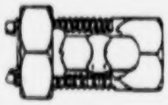
c. ______________________



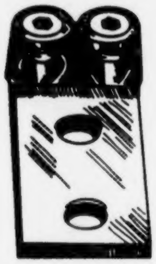
d. ______________________



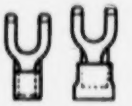
e. ______________________



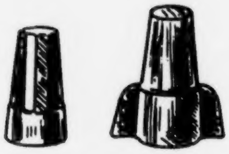
f. ______________________



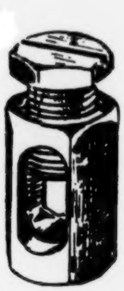
g. ______________________



h. ______________________

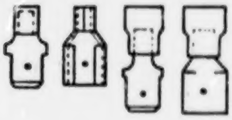


i. ______________________



j. 777______________________

Written Test



k. ______________________

5. Identify types of insulation, given its characteristics, applications, and code letters. Write the correct insulation names in the left-hand column.

Insulation Type	Code Letters	Application	Characteristics
a.	TW	Dry and wet locations	Flame retardant; moisture resistant; no outer covering
b.	THHN	Dry and damp locations	Flame retardant; heat resistant; nylon jacket
c.	THHW	Wet and dry locations	Flame retardant; moisture- and heat-resistant; no outer covering
d.	MTW	Machine tool wiring in wet locations as permitted in NFPA Standard No. 79 (See Article 670.) Machine tool wiring in dry location as permitted in NFPA Standard No. 79 (See Article 670.)	Flame retardant; moisture, heat, and oil resistant; wet applications, no outer covering; dry applications, nylon jacket
e.	THW	Dry and wet locations Special applications within electric discharge lighting equipment; limited to 1,000 open-circuit volts or less (size 14-8 only as permitted in Section 410-31)	Flame retardant; moisture and heat resistant; no outer covering
f.	THWN	Dry and wet locations	Flame retardant; moisture and heat resistant; nylon jacket

Written Test

6. List three conductors commonly found in electrical wiring.

   a. ______________________________

   b. ______________________________

   c. ______________________________

7. Match with their uses types of cables found in the electrical field. Write the correct numbers in the blanks.

   ______a. Dry and wet locations; suitable for burial

   ______b. Dry locations; used in majority of residential interior wiring

   ______c. Used for power, lighting, control, signal, and communication circuits

   ______d. Dry and wet locations; used for services, feeders, and branch circuits

   ______e. Dry locations; used for branch circuits and feeders in both exposed and concealed work

   ______f. Dry and wet locations; used for service-entrance conductors where applicable

   1. Nonmetallic-sheathed (NM and NMC)
   2. Underground feeder and branch circuit (UF)
   3. Service-entrance (SE and USE)
   4. Armored (AC)
   5. Mineral insulated, metal-sheathed (MI)
   6. Power and control tray (TC)

8. Select true statements about cords and their conductors. Write an "X" in the blank before each true statement.

   ______a. Cords used in a grounded system must have an identified grounded conductor.

   ______b. Cords that have a conductor with red or red with yellow striped insulation shall use that conductor for grounding only.

   ______c. Ungrounded conductors can be any color that is designated for grounded or grounding conductors.

   ______d. Cords should be used within their amp and insulation rating or classification.

Written Test

9. Complete the following statements about cables and their conductors. Write in the blanks the word(s) that best completes each statement.

   a. When used in a grounded system, an ________________________ grounded conductor (white or natural gray) must be in the cable.

   b. A bare or ________________________ conductor is always used as the equipment grounding conductor.

   c. ________________________ conductors can be any color other than those designated for grounded or grounding conductors.

   d. Cables should be used within their ________________________ and ________________________ rating.

*Permission to duplicate this test is granted.

Conductors
Unit 12

Unit Evaluation Form

Student Name ______________________________ Unit Rating ____________

Assignment Sheet 1—Select Conductors for Various Ampacities and Temperatures Rating ______

Comments: ____

Assignment Sheet 2—Calculate Ampacity of Conductors, Given Number of Conductors in Raceway Rating ______

Comments: ____

Assignment Sheet 3—Calculate Ampacity and Conductor Sizes for Specific Types of Loads Rating ______

Comments: ____

Assignment Sheet 4—Select Cords for Various Applications Rating ______

Comments: ____

Assignment Sheet 5—Select Proper Types of Insulation Rating ______

Comments: ____

Job Sheet 1—Install Cord on Utilization Equipment Rating ______

Comments: ____

Job Sheet 2—Use a Fish Tape to Install Wire in Conduit Rating ______

Comments: ____

Unit Evaluation Form

Job Sheet 3—Prepare an Aluminum Conductor for Termination Rating ______

Comments: ______________________________

____

Written Test Scores

Pretest ______ Posttest ______ Other ______

Other ______________________________

____

Teacher Signature ______________________________ Date ____________

Student Signature ______________________________ Date ____________

*Permission to duplicate this form is granted.

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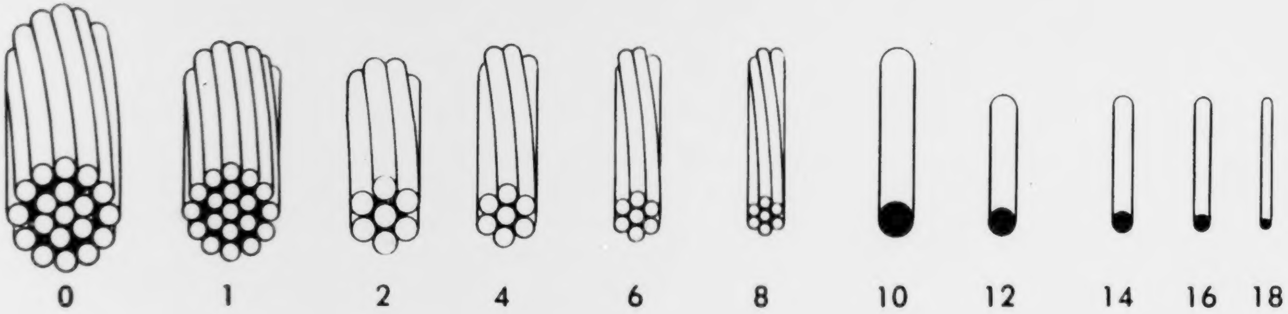
AWG Conductor Sizes


0
1
2
4
6
8
10
12
14
16
18

Actual Diameters of
Typical Sizes of Electric Wires Without Insulation

Conductors
Unit 12

Information Sheet

1. **Terms and definitions**

   a. **Aluminum wire** — Conductor made of aluminum

   b. **Ampacity** — The current, in amperes, that a conductor can carry continuously under the conditions of use without exceeding its temperature rating

   c. **American wire gauge (AWG)** — A series of specified diameters and thicknesses established as a standard in the United States; also known as Brown and Sharp gauge (B and S gauge)

   d. **Bare conductor** — A conductor having no covering or electrical insulation

   e. **Cable** — A factory assembly of two or more insulated conductors having an outer sheath of moisture-resistant, flame-retardant, nonmetallic material

   f. **Circular mils** — The diameter of a conductor in thousandths of inches multiplied times itself

   g. **Color coding** — Assigning colors to conductors based on their uses

   h. **Copper-clad aluminum** — Aluminum conductor with an outer coating of copper metallurgically bonded to the aluminum core

   i. **Copper wire** — Conductor made of copper

   j. **Cord** — Two- (or more) stranded conductors grouped together in a flexible covering

   k. **Covered** — Conductor encased within material of composition and thickness not recognized by the *NEC* as electrical insulation

   l. **Fish tape** — Long tape of steel, nylon, or other material used to push or pull a conductor into a raceway

   m. **Grounded conductor** — A system or circuit conductor that is intentionally grounded (connected to the earth or some conductor that serves in place of the earth)

   Note: An insulated grounded conductor of No. 6 or smaller shall be identified by continuous white or natural gray outer finish along its entire length. Insulated grounded conductors larger than No. 6 will be identified by a continuous white or natural gray outer finish or at the time of installation by a distinctive white marking at its termination.

Information Sheet

n. **Grounding conductor** — Conductor used to connect equipment or the grounded circuit of a wiring system to a grounding electrode or electrodes

Note: Unless bare, equipment grounding conductors will be green or green with one or more yellow stripes.

o. **Insulated** — Conductor encased within material of composition and thickness recognized by the *NEC* as electrical insulation

p. **Mil** — One thousandth of an inch

q. **Type letter** — Identification accepted by the trade in referring to the particular types of insulation

2. **Factors that determine conductor type and size**

Note: *NEC* Table 310-16 covers sizing for most general wiring for 60°C (140°F) to 90°C (194°F) temperature ranges.

a. Full load amperes

b. Number of conductors

Note: See *NEC* Table 310-16, Note 8.

c. Type of load served

Examples: *NEC* 424-3(b) — Fixed electric space-heating requires conductors for not less than 125 percent of full load.

NEC 430-22 — Single motors require conductors for 125 percent of full-load ampacity.

NEC 430-24 — Two or more motors require conductors with an ampacity at least equal to the sum of the full-load current rating of all the motors, plus 25 percent of the highest rated motor, plus the ampere rating of other loads.

d. Length of run

Note: See *NEC* Articles 210-19 and 215-2.

Information Sheet

e. Ambient temperature

Note: See *NEC* Tables 310-16 - 310-19.

Examples: Rooftop temperatures in summer approach the water boiling point of (100°C) 212°F.

Boiler and furnace rooms may reach temperatures near 100°C (212°F)

f. Voltage

Note: Most conductors for general use are rated for 600 volts. Higher voltage ratings are generally specified on a special order.

3. Characteristics of good connections

a. Are clean

b. Are tight

c. Are strong

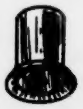
d. Provide full contact

e. Use approved devices and oxidation inhibitors when connected copper to aluminum

4. Types of connectors, terminals, and lugs (Figures 1-11)

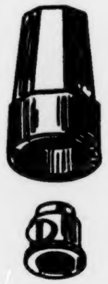
a. Crimp sleeve connector

Figure 1



b. Set-screw lug

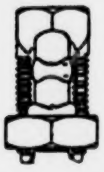
Figure 2



Information Sheet

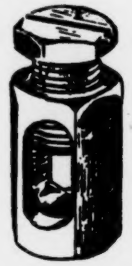
c. Split-bolt lug

Figure 3



d. Service-entrance lug

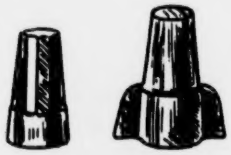
Figure 4



e. Wire-nut lugs

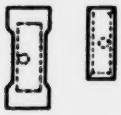
Note: These lugs are available in many configurations and sizes.

Figure 5



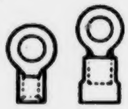
f. Crimp-type butt connectors

Figure 6



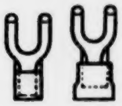
g. Ring lugs

Figure 7



h. Spade connectors

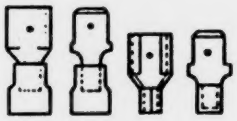
Figure 8



Information Sheet

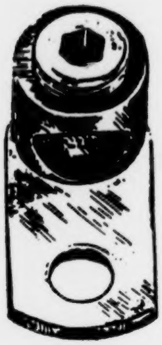
i. Quick disconnect connectors

Figure 9



j. Single terminal

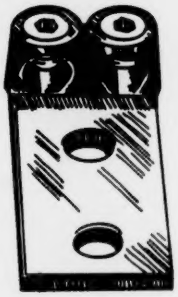
Figure 10



k. Twin or double terminal

Note: Twin terminals are available in many configurations.

Figure 11



Information Sheet

5. Types of insulation

Insulation Type	Code Letters	Application	Characteristics
Moisture-resistant thermoplastic	TW	Dry and wet locations	Flame retardant; moisture resistant; no outer covering
Heat-resistant thermoplastic	THHN	Dry and damp locations	Flame retardant; heat resistant; nylon jacket
Moisture- and heat-resistant thermoplastic	THHW	Wet and dry locations	Flame retardant; moisture and heat resistant; no outer covering
Moisture-, heat-, and oil-resistant thermoplastic	MTW	Machine tool wiring in wet locations as permitted in NFPA Standard No. 79 (See Article 670.) Machine tool wiring in dry location as permitted in NFPA Standard No. 79 (See Article 670.)	Flame retardant; moisture, heat, and oil resistant; wet applications, no outer covering; dry applications, nylon jacket
Moisture-, and heat-resistant thermoplastic	THW	Dry and wet locations Special applications within electric discharge lighting equipment; limited to 1,000 open-circuit volts or less (size 14-8 only as permitted in Section 410-31)	Flame retardant; moisture and heat resistant; no outer covering
Moisture- and heat-resistant thermoplastic	THWN	Dry and wet locations	Flame retardant; moisture and heat resistant; nylon jacket

6. Conductors commonly found in electrical wiring

a. Copper

b. Aluminum

c. Copper-clad aluminum

Information Sheet

7. Types and uses of cables found in the electrical field

a. Nonmetallic-sheathed cable (NM and NMC)

Note: Refer to *NEC* Article 336.

- Dry locations
- Majority of residential interior wiring

  Note: The insulated conductors shall be one of the types listed in Table 310-13 suitable for branch circuit wiring or one identified for use in these cables. Conductors shall be rated 90°C (194°F). The ampacity of types NM and NMC cable shall be that of 60°C (140°F) conductors and shall comply with section 310-15.

b. Underground feeder and branch-circuit cable (UF)

Note: Refer to *NEC* Article 339.

- Dry and wet locations
- Suitable for burial

c. Service-entrance cable (SE and USE)

Note: Refer to *NEC* Article 338.

- Dry and wet locations
- Service-entrance conductors where applicable

d. Armored cable (AC)

Note: Refer to *NEC* Article 333.

- Dry locations
- Branch circuits and feeders in both exposed and concealed work

Information Sheet

e. Mineral-insulated, metal-sheathed cable (MI)

Note: Refer to *NEC* Article 330.

- Dry and wet locations
- Service feeders and branch circuits

f. Power and control tray cable (TC) — Power, lighting, control, signal, and communication circuits

Note: Refer to *NEC* Article 340.

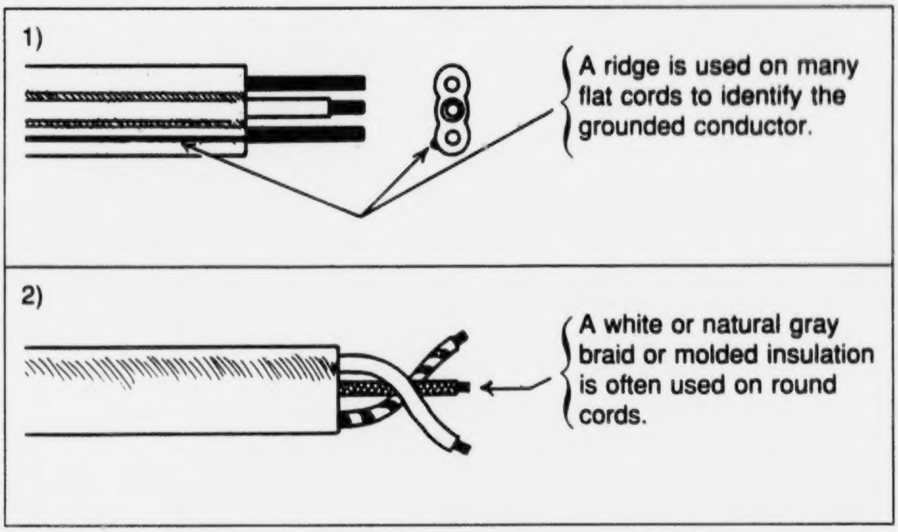
8. **Cords and their conductors** (Figures 12 and 13)

Note: Refer to *NEC* Article 400.

a. Cords used in a grounded system must have an identified grounded conductor.

Note: Grounded-conductor identification (a) through (f) describes acceptable methods for identifying grounded conductors.

Figure 12



A ridge is used on many flat cords to identify the grounded conductor.

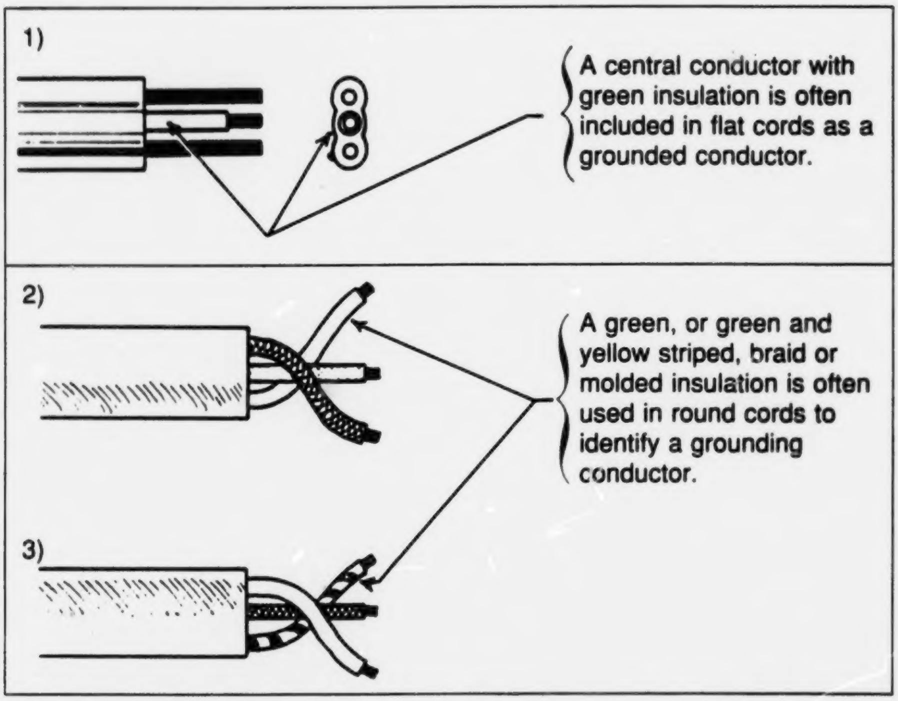
A white or natural gray braid or molded insulation is often used on round cords.

Information Sheet

b. Cords that have a conductor with green, or green with yellow striped, insulation shall use that conductor for grounding purposes only.

Note: Refer to *NEC* Article 400-23.

Figure 13



A central conductor with green insulation is often included in flat cords as a grounded conductor.

A green, or green and yellow striped, braid or molded insulation is often used in round cords to identify a grounding conductor.

c. Ungrounded conductors can be any color other than those designated for grounded or grounding conductors.

d. Cords should be used within their amp and insulation rating or classification.

Note: Refer to *NEC* Table 400-5.

9. Cables and their conductors

a. When used in a grounded system, an identified grounded conductor (white or natural gray) must be in the cable.

b. A bare or green conductor is always used as the equipment grounding conductor.

Information Sheet

c. Ungrounded conductors can be any color other than those designated for grounded or grounding conductors.

d. Cables should be used within their amp and condition rating.

Conductors
Unit 12

Assignment Sheet 1—Select Conductors for Various Ampacities and Temperatures

Name ______________________________ Overall Rating __________

Evaluation criteria	Rating
Assignment answers complete	______
Minimum of ten of eleven answers correct per Answers to Assignment Sheet 1	______

The electrical worker must be able to select proper conductors for various ampacities and temperatures. This skill requires that the technician be able to locate and read *National Electrical Code* tables.

Directions: Select conductors for various ampacities and temperatures. Use the *National Electrical Code*, Tables 310-16 to 310-19 for not more than three conductors in a raceway. Use the temperature rating column that is the same or the next higher rating than the required temperature, then select the size conductor for the required or next higher ampacity. Refer only to the sizes given for copper wiring.

Examples: What wire size is required for a load of 55 amperes at 30°C? The answer is #6 AWG. This is obtained by referring to the 60°C column because the required temperature is not above 60°C. You must then check the ampacity correction factor. Since the temperature is not over 30°C you may use the amperage listed in Table 310-16 of 55 amperes for #6.

What wire size is required for a load of 25 amperes at 68°F? The answer is #10 AWG. Although the chart under the 167°F column shows that #12 AWG is acceptable for 25 amperes at this temperature, the obelisk (†) indicates a note below the table. According to the note, the overcurrent protection for each type of conductor shown shall not exceed 20 amperes for #12 AWG wire. Thus, you will need to use the next heavier gauge, #10 AWG, which provides overcurrent protection up to 30 amperes.

Assignment Sheet 1

Amperes	Temperature	Wire Size Per *NEC* 310-16 to 310-19
20	65°C	A. ________________
35	75°C	B. ________________
37	85°C	C. ________________
110	87°C	D. ________________
110	65°C	E. ________________
232	75°C	F. ________________
400	85°C	G. ________________
540	60°C	H. ________________
67	65°C	I. ________________
83	75°C	J. ________________
190	70°C	K. ________________

Conductors
Unit 12

Assignment Sheet 2—Calculate Ampacity of Conductors, Given Number of Conductors in Raceway

Name ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
Assignment answers complete	______
Minimum of eleven of twelve answers correct per Answers to Assignment Sheet 1	______

The electrical worker must be able to calculate the ampacity of conductors, given various numbers in the raceway. This skill requires that the technician be able to locate and read *National Electrical Code* tables.

Directions: Use the *National Electrical Code*, Table 310-16 and Note 8 following the tables to calculate ampacity of conductors, given various numbers in a raceway. Complete the chart below using the values given for copper wire, type THW.

THW#	Number in Raceway	Ampacity	Number in Raceway	Ampacity
8	3	A. __________	6	G. __________
10	3	B. __________	27	H. __________
4	3	C. __________	9	I. __________
00	3	D. __________	8	J. __________
250 kcmil	3	E. __________	8	K. __________
3	3	F. __________	17	L. __________

Conductors
Unit 12

Assignment Sheet 3—Calculate Ampacity and Conductor Sizes for Specific Types of Loads

Name ______________________________ Overall Rating __________

Evaluation criteria	Rating
Assignment answers complete	______
Part 1 Minimum of two of three answers correct per Answers to Assignment Sheet 3	______
Part 2 Minimum of four of five answers correct per Answers to Assignment Sheet 3	______

The electrical worker must be able to calculate ampacity and conductor size for various types of loads. This skill requires that the technician be able to locate and read *National Electrical Code* tables.

Directions: Use the *National Electrical Code*, Article 424-3(a) and (b), Article 430-22, and Tables 310-16 and 430-22(a) to calculate ampacities and copper conductor sizes for the specific types of loads listed below.

Part 1

Full-Load Amperes	Fixed Electric Space Heater Amperes	Size of 85°C Conductor
A. 27	________________	________________
B. 65	________________	________________
C. 72	________________	________________

Assignment Sheet 3

Part 2

Single Motor Load Amperes	Type of Motor	Percent Full-Load Motor Amperes	Size of 85°C Conductor
A. 43	Elevator motor, continuous rated	________	________
B. 90	Varying duty, 30-60 minute rated	________	________
C. 110	Pump motor, 5 minute rated	________	________
D. 86	Valve motor, 15 minute rated	________	________
E. 27	Metal roll, 30-60 minute rated	________	________

Conductors
Unit 12

Assignment Sheet 4—Select Cords for Various Applications

Name ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
Assignment answers complete	______
All four answers correct per Answers to Assignment Sheet 4	______

The electrical worker must be able to select cords based on ampacity and usage conditions.

Directions: Using Tables 400-4 and 400-5 in the *NEC*, select the proper cord type letter and conductor size for the various conditions described below.

Note: Type letter blanks may have more than one answer.

	Machine	**Type**	**Size**
A.	Machine shop where cutting oil is used; load 28 amps	__________	__________
B.	Computer room; load 16 amps	__________	__________
C.	Commercial kitchen; load 54 amps	__________	__________
D.	Elevator lighting; load 15 amps	__________	__________

Conductors
Unit 12

Assignment Sheet 5—Select Proper Types of Insulation

Name ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
Assignment answers complete	______
Minimum of four of five answers correct per Answers to Assignment Sheet 5	______

The electrical worker must be able to select insulation according to its intended use.

Part 1

Directions: Using Table 310-13 in the *National Electrical Code*, select proper insulation types for each of the following situations. Several insulation types may apply.

A. Boiler room where there is high humidity and high heat

____

B. Machine shop where there is cutting oil in use

____

C. Computer room with normal heat and humidity

____

D. Car wash with normal temperatures and high humidity

____

E. Commercial kitchen with high temperature and normal humidity

____

Assignment Sheet 5

Part 2

Use the *National Electrical Code*, Table 310-13 to find temperature rating in degrees centigrade and degrees Fahrenheit for each of the following insulation types, under normal uses.

	Type	°C	°F
A.	TFE		
B.	TW		
C.	THW (dry and wet location)		
D.	THHN		
E.	MTW (wet location)		
F.	RHH		
G.	THWN		
H.	TA		
I.	ZW (dry location, special applications)		
J.	XHHW (wet location)		
K.	SA (special applications)		
L.	MI (dry and wet location)		
M.	USE		
N.	PFA (dry and wet location)		
O.	THHW (wet location)		

Conductors
Unit 12

Job Sheet 1—Install Cord on Utilization Equipment

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Gathered and used appropriate equipment and materials	______
Performed procedure safely	______
Performed all steps in procedure	______
Cleaned work area	______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the above criteria.

A. Equipment and materials

Pouch tools
Cord connector
Wire nuts
Small fixed appliance
Safety glasses
Appropriate appliance cord

Note: Cord must be acceptable to the *NEC* and local code enforcing agent.

B. Procedure

☐ 1. Gather tools and equipment and put on safety glasses.

☐ 2. Locate appliance manufacturer's specification plate.

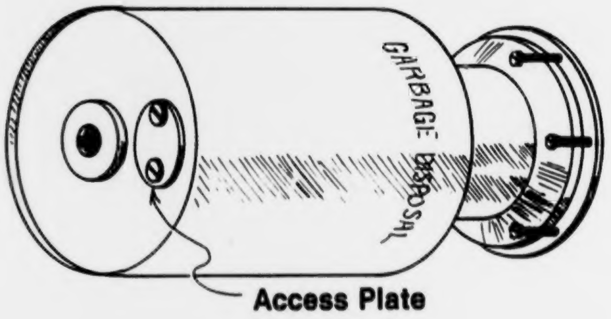
☐ 3. Compare appliance specifications to cord selected.

Note: Be sure that the cord will reach the outlet you plan on using.

Job Sheet 1

☐ 4. Remove access plate from appliance. (Figure 1)

Figure 1



☐ 5. Install cord connector.

☐ 6. Connect cord conductors to appropriate appliance terminals or conductors.

☐ 7. Adjust cord inside unit.

Note: Make sure that all conductors are free moving and not cramped.

☐ 8. Tighten cord connector.

☐ 9. Replace access plate.

Note: If an equipment grounding terminal is not provided inside the unit termination space, you can add a grounding terminal.

☐ 10. Plug unit into appropriate receptacle.

Note: Be sure to plug it into the switched receptacle

☐ 11. Test appliance for correct operation.

Note: If installing cord on a garbage disposal, run water into the disposal as you test it.

☐ 12. Clean work area, and return equipment and materials to proper storage.

Evaluator's comments: ______________________________

____

____

Conductors
Unit 12

Job Sheet 2—Use a Fish Tape to Install Wire in Conduit

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Gathered and used appropriate equipment and materials	______
Performed procedure safely	______
Performed all steps in procedure	______
Cleaned work area	______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the above criteria.

A. Equipment and materials

60 feet of conduit
Steel fish tape, 100 or 200 feet long
500 feet of #10 THHN wire
Pouch tools
Electrician's knife
Wire-pulling compound

B. Procedure

Note: Work in teams of three or more.

☐ 1. Cut six 70-foot pieces of #10 THHN.

☐ 2. Lay out wire at feed-in end of conduit run, straight enough to be installed without kinking or becoming tangled.

☐ 3. Push fish tape into opposite end of conduit run.

Note: If it is difficult to push the tape around the last 90-degree bend, grip the fish tape with lineman's pliers about 1 or 2 inches from the end and push; or while pushing on fish tape, have someone tap on conduit near the 90-degree bend where the difficulty seems to be.

Job Sheet 2

☐ 4. Skin back about 5 inches of insulation on each wire at fish-tape-connection end.

5. Attach wires to fish-tape eye.

   ☐ • Squeeze bent wires, making joint the smallest size practical.

   ☐ • Apply tape tightly from conductor toward fish tape.

   Note: Taping tightly leaves the tape with no leading edges to make pulling more difficult.

☐ 6. Lubricate the connection.

☐ 7. Pull fish tape very slowly at first to get the connection into the conduit.

Note: The feed-in person can help by pushing slightly on conductors. When pulling fish tape, exert a smooth steady pull; do not jerk.

☐ 8. Pull until conductor is through conduit at appropriate length.

Note: Have instructor evaluate your work.

☐ 9. Clean work area, and return equipment and materials to proper storage.

Evaluator's comments: ____

____

____

Conductors
Unit 12

Job Sheet 3—Prepare an Aluminum Conductor for Termination

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Gathered and used appropriate equipment and materials	______
Performed procedure safely	______
Performed all steps in procedure	______
Cleaned work area	______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the above criteria.

A. Equipment and materials

Pouch tools
Electrician's knife
Wire brush
Antioxidant (oxiban or equivalent)
#2 single-lug terminal, copper or aluminum

B. Procedure

☐ 1. Remove ¾ inch of insulation from conductor with knife.

Note: Do not circle the conductor with the knife. This usually nicks the wire strands and reduces their strength and conducting capacity.

☐ 2. Remove any oxide coating with wire brush.

Note: Oxide coating is a dark, dull coating. It is important to remove it because aluminum oxidizes rapidly.

☐ 3. Apply antioxidant to conductor.

Job Sheet 3

☐ 4. Insert conductor in lug and tighten per manufacturer's torque specifications.

☐ 5. Allow several minutes to elapse and then retighten.

Note: The strands will settle into place making a second tightening necessary.

☐ 6. Clean work area, and return equipment and materials to proper storage.

Evaluator's comments: ____

____

____

Low Voltage Wiring
Unit 13

Objective Sheet

Unit Objective

After completing this unit, the student should be able to install low voltage wiring systems in a residence. The student should demonstrate these competencies by completing the assignment and job sheets and scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to low voltage wiring circuits with their correct definitions.
2. Identify the parts of a low voltage wiring system.
3. Describe the process that takes place during a low voltage lighting circuit off/on cycle.
4. Describe the process that takes place during the energizing of a chime circuit.
5. Complete a thermostat drawing of the manual fan switching circuit to indicate the current flow path through the fan control switch and fan relay.
6. Complete a thermostat drawing to indicate the current flow path with the thermostat system switch in the cool position and the fan switch on auto.
7. Complete a thermostat drawing to indicate the current flow path with the thermostat system switch in the heat position and the fan switch on auto.
8. Complete statements about anticipator circuits on low voltage thermostats.
9. Match communication circuits with their characteristics.
10. Complete statements about smoke and fire alarm systems.
11. Select true statements about the operation of a garage door opener.
12. Draw a wiring diagram indicating the proper connection for bell circuit equipment. (Assignment Sheet 1)
13. Wire a two-switch low voltage lighting circuit. (Job Sheet 1)

Objective Sheet

14. Wire a two-button chime circuit. (Job Sheet 2)
15. Determine heat anticipator current draw. (Job Sheet 3)
16. Install a wall thermostat. (Job Sheet 4)

Low Voltage Wiring
Unit 13

Suggested Activities

Instructional Plan

Preparation

1. Read the unit carefully and plan for instruction. Study the specific objectives to determine the order in which you will present them.
2. Review Teaching Suggestions section that follows. Plan for classroom activities.
3. Plan your presentation to take advantage of student learning styles and to accommodate special needs students.
4. Make transparencies from the transparency masters included with this unit. These appear in the teacher edition only and are designed to be used with the following objectives:

   TM 1—Low Voltage Off/On Switching Cycle (Objective 3)
   TM 2—Thermostat: Manual Fan Control (Objective 5)
   TM 3—Thermostat: Cooling Circuit with Automatic Fan Control (Objective 6)
   TM 4—Thermostat: Heating Circuit with Automatic Fan Control (Objective 7)

5. Obtain films, videotapes, and other resources to supplement instruction of this unit. See ordering information in the Suggested Supplemental Resources section that follows.
6. Develop teaching plan. Adjust for different learning styles.
7. Make copies of Unit Evaluation Form.

Delivery and Application

8. Provide students with unit of instruction.
9. Discuss unit and specific objectives.
10. Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
11. Discuss the assignment sheets. Review criteria for evaluation of these activities.
12. Discuss and demonstrate the job sheets. Review criteria for evaluation of these activities.

Suggested Activities

Evaluation

13. Discuss the use of the Unit Evaluation Form with students. Discuss the rating scale that will be used for student evaluation.

14. Make copies of the written test. Add or modify test items as needed.

15. Give written test.

16. Compile assignment and job sheet ratings and written test scores on the Unit Evaluation Form. Add any additional assignments or supplemental activities that should be part of the unit evaluation.

17. Reteach and retest as required.

Teaching Suggestions

Note: Skill areas appearing in boldface type in the Teaching Suggestions refer to the academic and workplace skills identified by the American Society for Training and Development (ASTD) and the U.S. Department of Labor. These have been adapted by MAVCC.

1. Contact a local sales distributor to visit the class and demonstrate low voltage lighting and signaling devices. Skill areas: **Listening, observing scientific applications**

2. Assign students to write a report on the advantages and disadvantages of low voltage lighting. Discuss student reports in class. Skill areas: **Writing, oral communication**

3. Contact a local telephone company representative to visit the class and demonstrate phone systems. Discuss local requirements for installation of the equipment and system. Skill areas: **Listening, observing scientific applications**

4. Contact a local C.A.T.V. (Community Antenna Television) cable system to visit the class and discuss the local requirements for installation of equipment and the connection to their system. Skill area: **Listening**

5. Plan an outside field trip to local phone company and C.A.T.V. cable system switching locations. Skill area: **Observing scientific applications**

Suggested Activities

Resources Used in Developing This Unit

1. Foley, Joseph H. *Electrical Wiring Fundamentals*. New York: Gregg McGraw-Hill Book Company.
2. Holzman, Harvey N. *Modern Residential Wiring*. South Holland, IL: Goodheart-Wilcox Company, Inc., 1986.
3. Mullin, Ray C. *Electrical Wiring: Residential*, Eighth Edition. Albany, NY: Delmar Publishers, Inc., 1984.
4. Taylor, Mark. *Residential Wiring*, Revised. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1983.

Suggested Supplemental Resources

1. Texts
    a. Crost, Terrell, ed. *American Electrician's Handbook*, 11th ed. New York: McGraw-Hill, 1987.
    b. Kubala, Thomas S. *Electricity 1: Devices, Circuits, and Materials*, Fourth Edition. Albany, NY: Delmar Publishers, Inc., 1986.

    Note: To order this text, write to: 2 Computer Drive West, Box 15-015, Albany, NY 12212.
2. Catalog — Hunzicker Brothers Catalog, 501 N. Virginia, Oklahoma City, OK 73125.
3. Filmstrip — *Electrical House Wiring Explained #804*. Bergwall Productions, Inc., 839 Stewart Ave., Garden City, NY 11530.

    Note: This filmstrip covers installation for signal systems, telephone, television, and smoke and fire detectors.
4. ERICO Products CAD Welding.
5. Software — *Electrical Wiring*. AAVIM, 745 Gaines School Road, Athens, GA 30605. Phone (800) 228-4689.

Suggested Activities

Instructions for Evaluating Student Performance

Assignment Sheets—Be sure the student understands the criteria on which the evaluation is based. Assign a point value to each criterion and convert the total points to a percentage for grading.

Job Sheets—Be sure the student understands the criteria on which the evaluation is based. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in either the teacher edition or student manual. Then observe the student performing the procedure. Rate both process and product.

> Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily achieved the step(s) for each checkpoint area. If the student is unable to correctly complete the procedure, have the student review the materials and try again.
>
> Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria which have been provided as part of the job sheet. Complete the rating by assigning a point value to each criterion and by converting the point total to a percentage for grading. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) which best fits your program needs.

Option A

4 - Skilled—Can perform job with no additional training.
3 - Moderately skilled—Has performed job during training program; limited additional training may be required.
2 - Limited skill—Has performed job during training program; additional training is required to develop skill.
1 - Unskilled—Is familiar with process, but is unable to perform job.

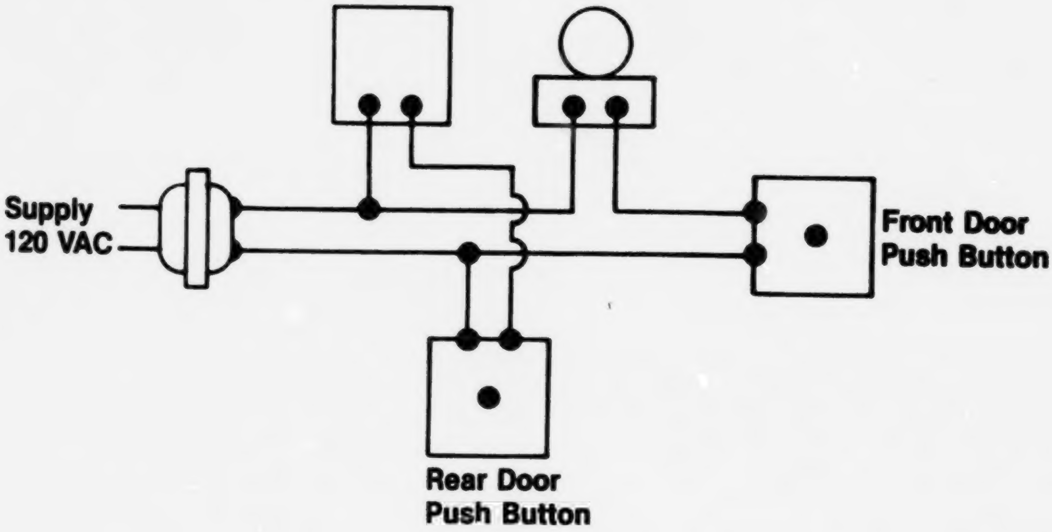
Option B

Yes—Can perform job with no additional training.

No—Is unable to perform job satisfactorily.

Low Voltage Wiring
Unit 13

Answer to Assignment Sheet 1


Supply
120 VAC
Front Door
Push Button
Rear Door
Push Button

Low Voltage Wiring
Unit 13

Answers to Written Test

1.

a.	9	f.	10
b.	5	g.	6
c.	7	h.	8
d.	4	i.	2
e.	3	j.	1

2.
   a. Transformer
   b. Low voltage lighting relay
   c. Low voltage cable
   d. Momentary contact switch

3. Description should include:

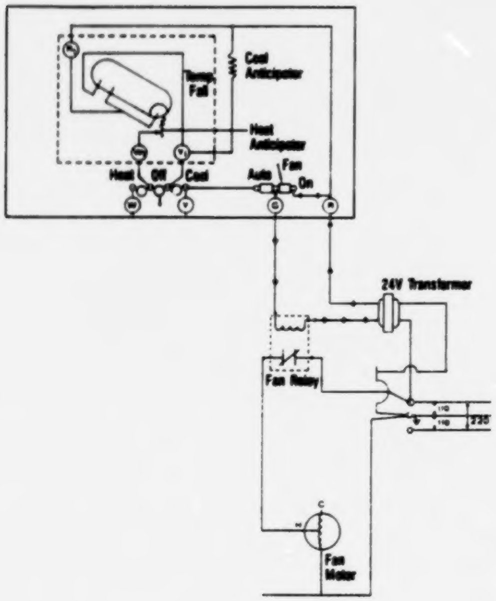
   a. "On" switch is pushed
      (1) Circuit is completed to closing movement of solenoid in relay
      (2) Core is moved and circuit is completed
   b. "Off" switch is pushed
      (1) Circuit is completed to opening movement of solenoid in relay
      (2) Core is moved and circuit is opened

4. Description should include:

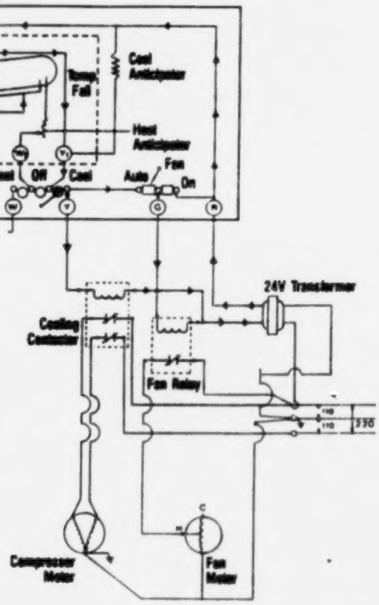
   a. Button is pushed
      (1) Circuit is completed to solenoid
      (2) Plunger is drawn down to chime and sound is made
   b. Button is released
      (1) Circuit is open
      (2) Spring pulls plunger up to upper chime and another sound is made

Answers to Written Test

5.

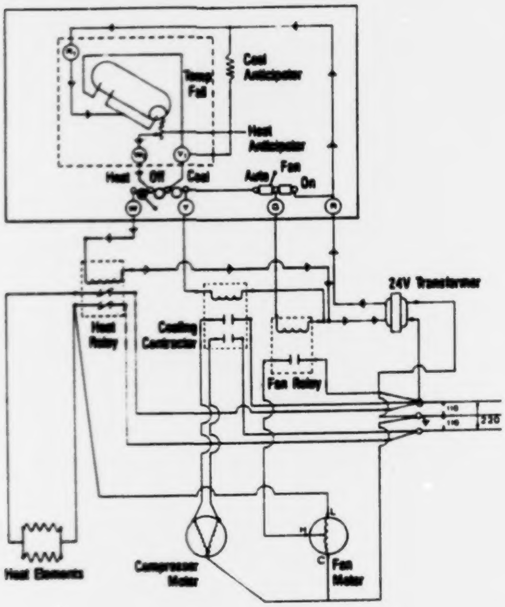

Cool Anticipator
Temp. Fall
Heat Anticipator
Heat
Off
Cool
Auto
Fan
On
W
Y
G
R
24V Transformer
Fan Relay
110
110
230
C
Fan Motor

6.


Cool Anticipator
Temp. Fall
Heat Anticipator
Heat
Off
Cool
Auto
Fan
On
W
Y
G
R
24V Transformer
Cooling Contactor
Fan Relay
110
110
230
C
Compressor Motor
Fan Motor

Answers to Written Test

7.


Cool Anticipator
Temp. Fall
Heat Anticipator
Heat
Off
Cool
Auto
Fan
On
24V Transformer
Heat Relay
Cooling Contractor
Fan Relay
110
110
230
L
H
C
Heat Elements
Compressor Motor
Fan Motor

8. a. Bimetallic lag
   b. (1) Parallel
      (2) Close
   c. (1) In series
      (2) Open

9. a. 3
   b. 3
   c. 1
   d. 2
   e. 3
   g. 1

10. a. Heat, smoke
    b. Heat
    c. Photoelectric, ionization
    d. Fire

11. b, d

Low Voltage Wiring
Unit 13

Written Test

Name ______________________________ Score ______________

1. Match terms related to low voltage wiring with their correct definitions. Write the correct numbers in the blanks.

______a. A device that senses temperature variations from a set point and, in turn, acts to control a circuit

______b. Electromagnetic device for remote or automatic control

______c. Electromagnetic cylinder that moves an iron plunger when current is applied

______d. Solenoid with two electromagnetic circuits that will pull or push a plunger depending on which magnet has circuits applied to it

______e. A switch that is closed or opened only while the operator touches it

______f. An electrical device used to step up or step down a primary voltage to a desired secondary voltage

______g. A fire warning device commonly used in a residence; available in two types: photoelectric or ionization

______h. A personal communication system installed in the home to provide outside conversation with the world

______i. A fire warning device commonly used in a residence; available in two types: fixed or rate-or-rise temperature detectors

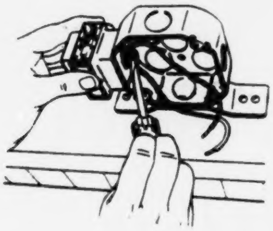
______j. Conductor used for carrying communication signals

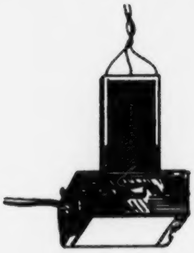
1. Coaxial cable
2. Heat detector
3. Momentary contact switch
4. Pull-push solenoid
5. Relay
6. Smoke detector
7. Solenoid
8. Telephone system
9. Thermostat
10. Transformer

819

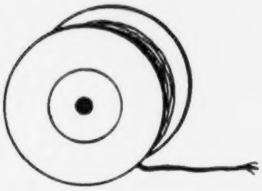
Written Test

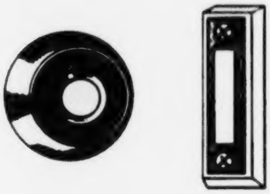
2. Identify the parts of a low voltage wiring system. Write the correct names in the blanks.





a. ______________________ b. ______________________





c. ______________________ d. ______________________

3. Describe the process that takes place during a low voltage lighting circuit off/on cycle.

____

____

____

____

4. Describe the process that takes place during the energizing of a chime circuit.

____

____

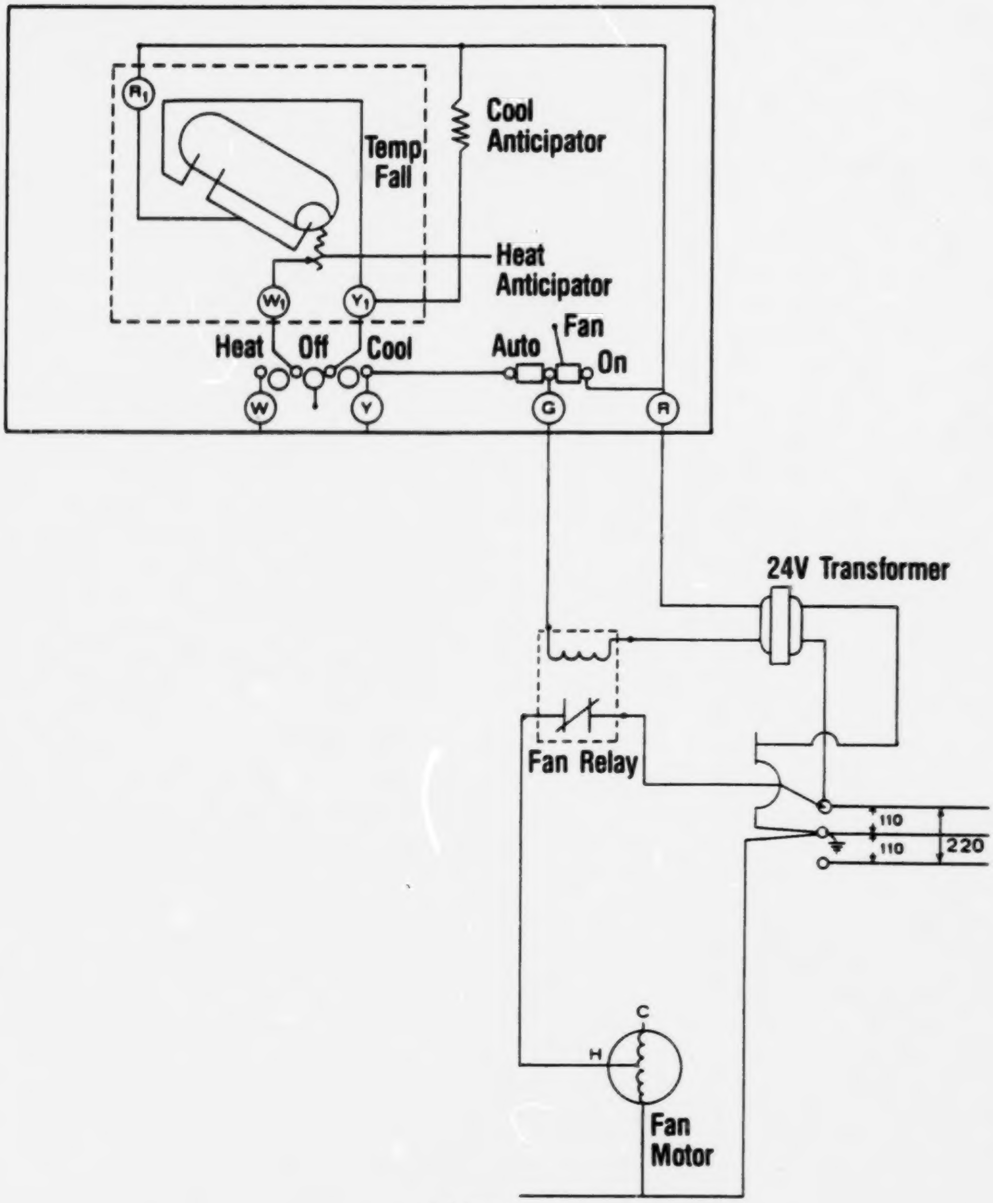
____

____

Written Test

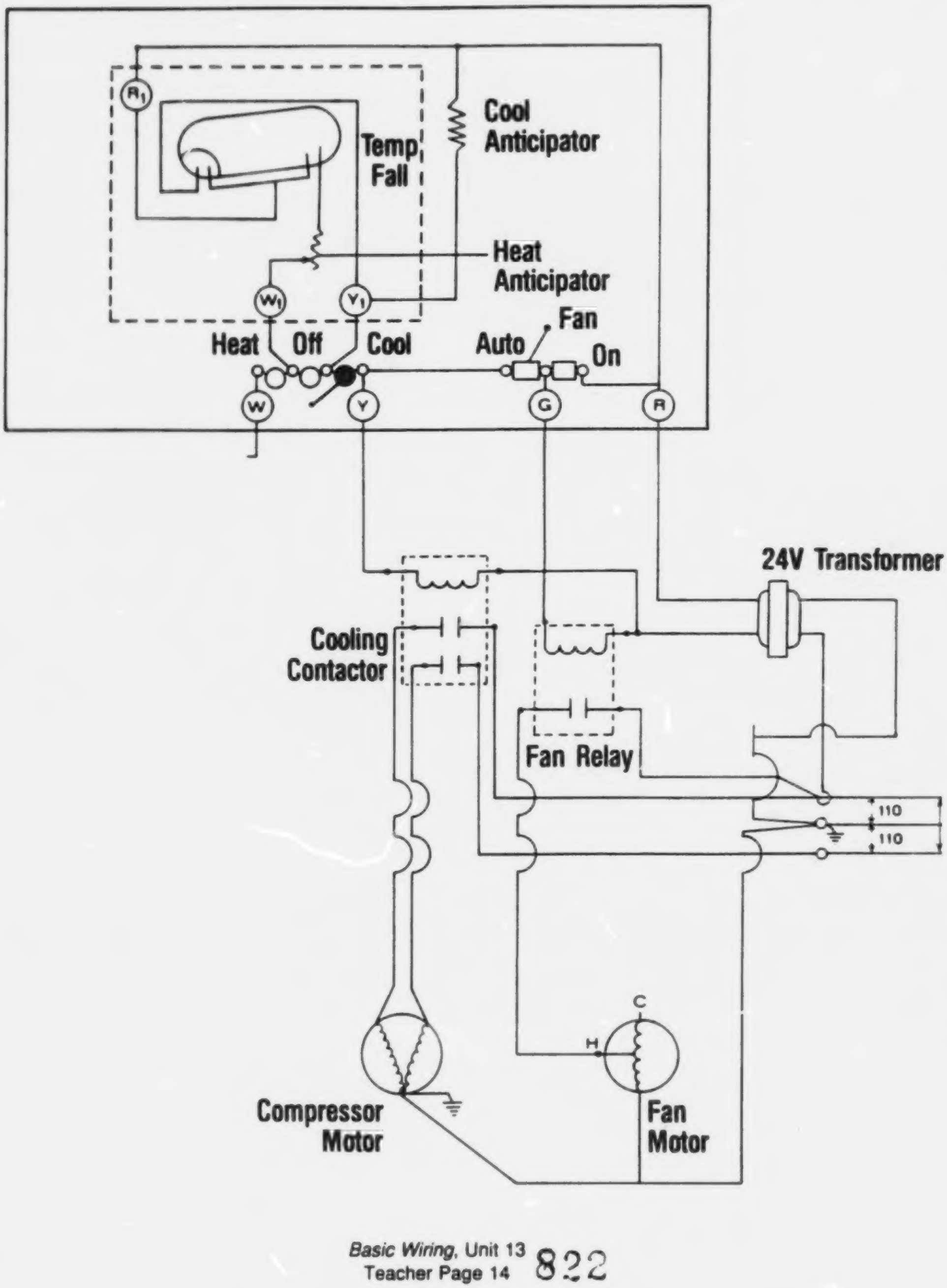
5. Complete a thermostat drawing of the manual fan switching circuit below to indicate the current flow path through the fan control switch and fan relay.

   Note: Let →→→ indicate current flow.


R1
Temp Fall
Cool Anticipator
Heat Anticipator
W1
Y1
Heat
Off
Cool
Auto
Fan
On
W
Y
G
R
24V Transformer
Fan Relay
110
110
220
C
H
Fan Motor

6. Complete the thermostat drawing below to indicate the current flow path with the thermostat system switch in the cool position and the fan switch on auto.

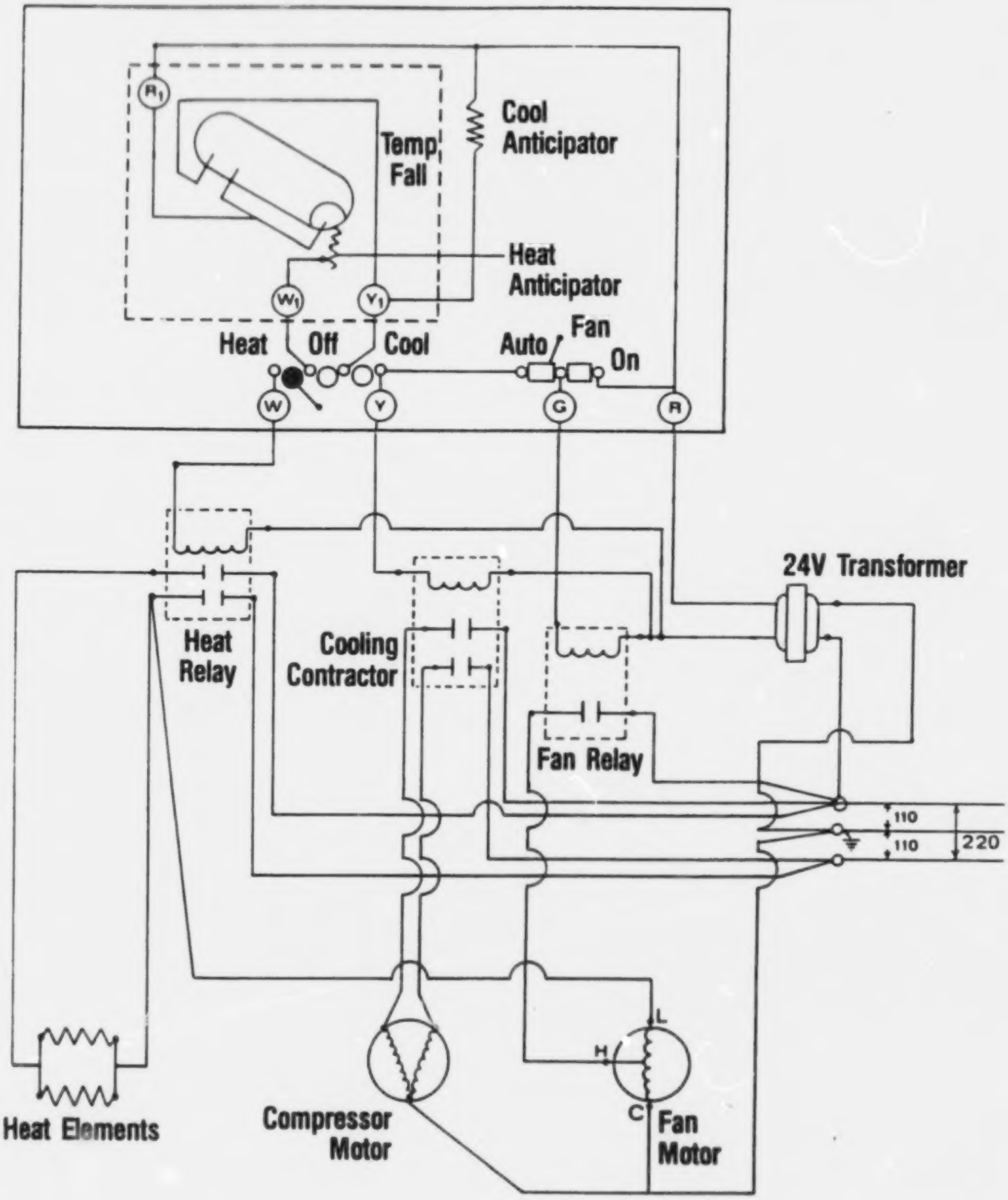
   Note: Show both fan and cooling relays closed.


R1
Temp Fall
Cool Anticipator
Heat Anticipator
W1
Y1
Heat
Off
Cool
Auto
Fan
On
W
Y
G
R
24V Transformer
Cooling Contactor
Fan Relay
110
110
C
H
Compressor Motor
Fan Motor

Written Test

7. Complete the thermostat drawing below to indicate the current flow paths with the thermostat system switch in the heat position and the fan switch on auto.

   Note: Show heat relay closed.


R₁
Temp Fall
Cool Anticipator
Heat Anticipator
W₁
Y₁
Heat
Off
Cool
Auto
Fan
On
W
Y
G
R
24V Transformer
Heat Relay
Cooling Contractor
Fan Relay
110
110
220
L
H
C
Heat Elements
Compressor Motor
Fan Motor

Written Test

8. Complete the following statements about anticipator circuits on low voltage thermostats. Write in the blanks the word(s) that best completes each statement.

   a. Heat and cool anticipators are installed to compensate for __________________.

   b. Cool anticipator

      (1) It is wired __________________ to mercury switch.

      (2) Heat causes bimetal to tilt bulb and __________________ circuit before room temperature actually reaches "on" temperature setting.

   c. Heat anticipator

      (1) It is wired __________________ to mercury switch.

      (2) Heat causes bimetal to tilt bulb and __________________ circuit before room temperature reaches desired room setting.

9. Match communication circuits with their characteristics. Write the correct numbers in the blanks.

______a. The point where the wiring ends and the home owner's interior wiring begins is called the "demarkation point."

______b. The circuit wiring is installed on two pair, 4-conductor, cable.

______c. This low voltage wiring system allows room-to-room two-way conversation in a residence.

______d. The cable types in this system are 300 ohm or 75 ohm.

______e. This system requires a separate pair of conductors all the way back to the company's switching center.

______f. This system may incorporate radio and tape playing with room monitoring.

1. Intercom
2. Television antenna
3. Telephone

Written Test

10. Complete the following statements about smoke and fire alarm systems. Write in the blanks the word(s) that best complete each statement.

    a. Fire warning devices commonly used in a residence are a ________________ detector and a ________________ detector.

    b. ________________ detectors sense a specific fixed temperature a rate-of-rise.

    c. The two most common types of smoke detectors are the ________________ type and the ________________ type.

    d. ________________ is the third leading cause of accidental fatalities.

11. Select true statements about the operation of a garage door opener. Write an "X" in the blank before each true statement.

    ______a. The opener contains a motor, radar controller, motor reversing switch, keynote speaker, radio operated controller, and electric brake.

    ______b. The electrically operated reversing switch can be controlled by push-button or key operated switch stations and radio operated controllers.

    ______c. The push-button or key operated station consists of a normally open momentary contact switch connected by 4-wire low voltage cable to the control unit.

    ______d. The radio-controlled operator consists of a transmitter of a set frequency. The receiver on the control unit is set for the corresponding frequency so that when the receiver detects a signal of that frequency, it will energize the motor in the opposite direction of its previous travel.

***Permission to duplicate this test is granted.**

Low Voltage Wiring
Unit 13

Unit Evaluation Form

Student Name ______________________ Unit Rating __________

Assignment Sheet 1—Draw a Wiring Diagram Indicating the Proper Connection for Bell Circuit Equipment Rating ______

Comments: ______________________

____

Job Sheet 1—Wire a Two-Switch Low Voltage Lighting Circuit Rating ______

Comments: ______________________

____

Job Sheet 2—Wire a Two-Button Chime Rating ______

Comments: ______________________

____

Job Sheet 3—Determine Heat Anticipator Current Draw Rating ______

Comments: ______________________

____

Job Sheet 4—Install a Wall Thermostat Rating ______

Comments: ______________________

____

Written Test Scores

Pretest ______ Posttest ______ Other ______

Other ______________________

____

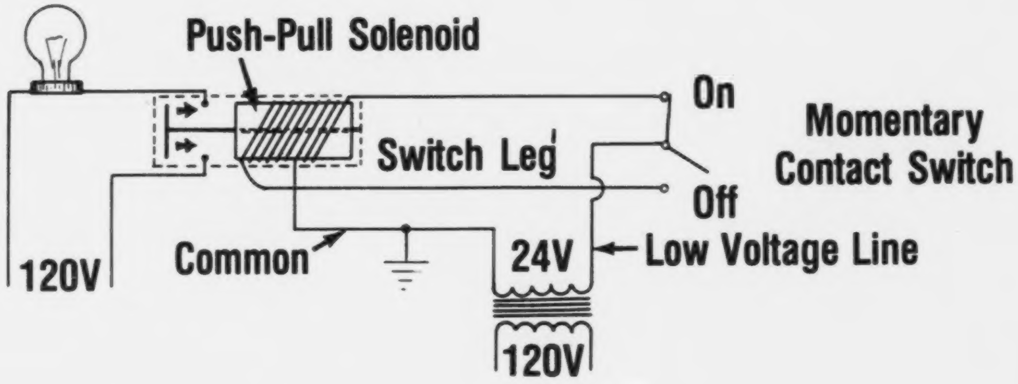
Teacher Signature ______________________ Date __________

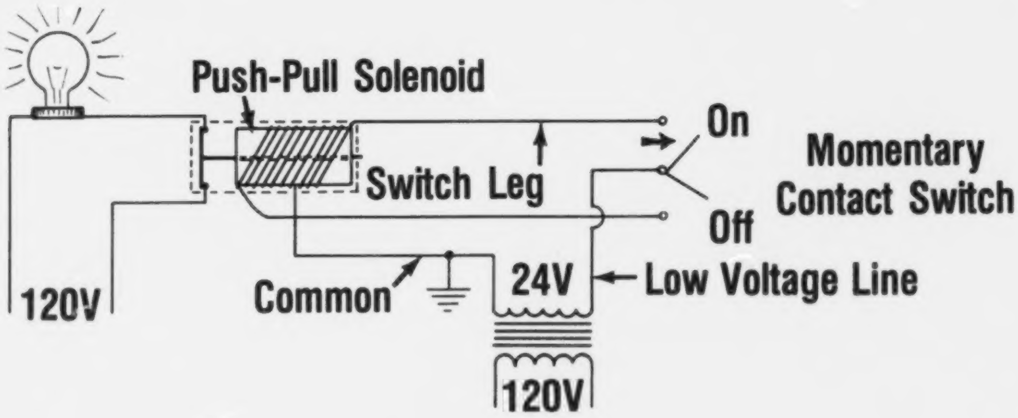
Student Signature ______________________ Date __________

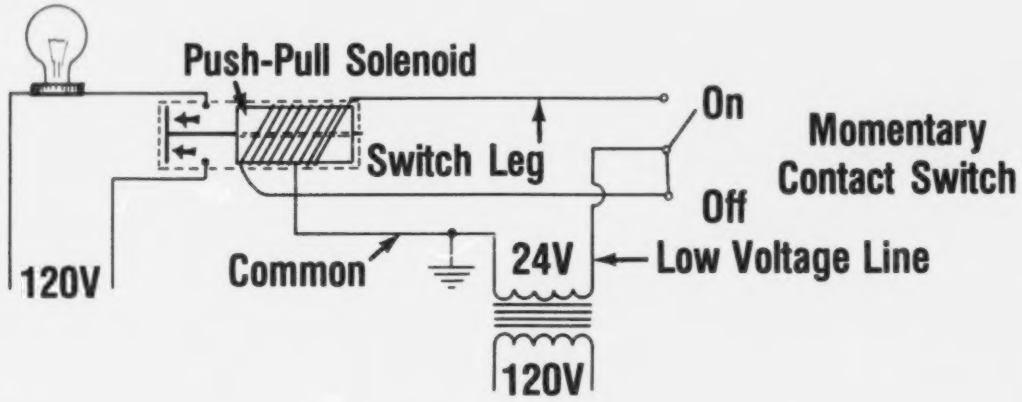
***Permission to duplicate this form is granted.**

826

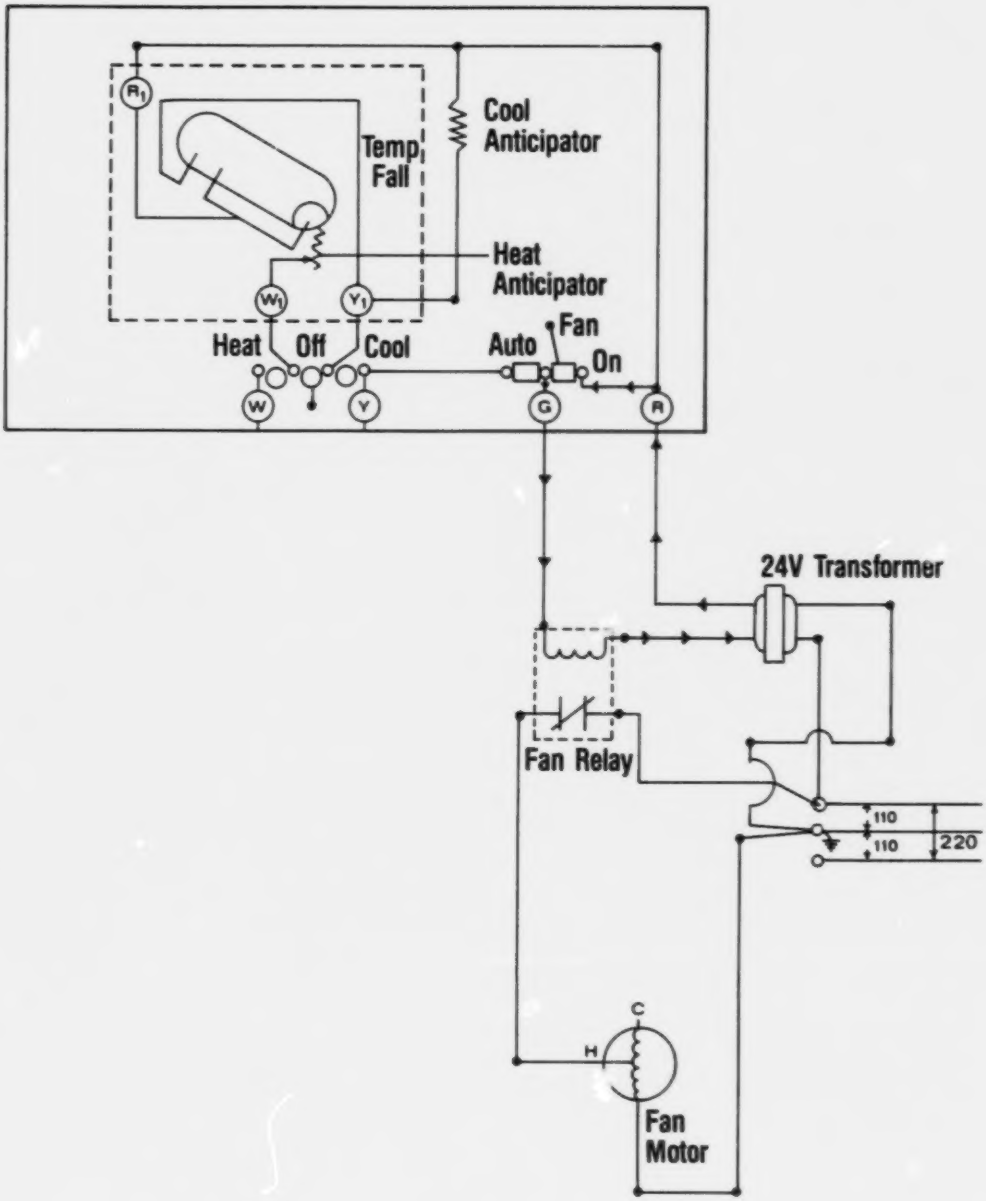
Low Voltage Off/On Switching Cycle


Push-Pull Solenoid
On
Momentary
Contact Switch
Switch Leg
Off
120V
Common
24V
Low Voltage Line
120V


Push-Pull Solenoid
On
Momentary
Contact Switch
Switch Leg
Off
120V
Common
24V
Low Voltage Line
120V

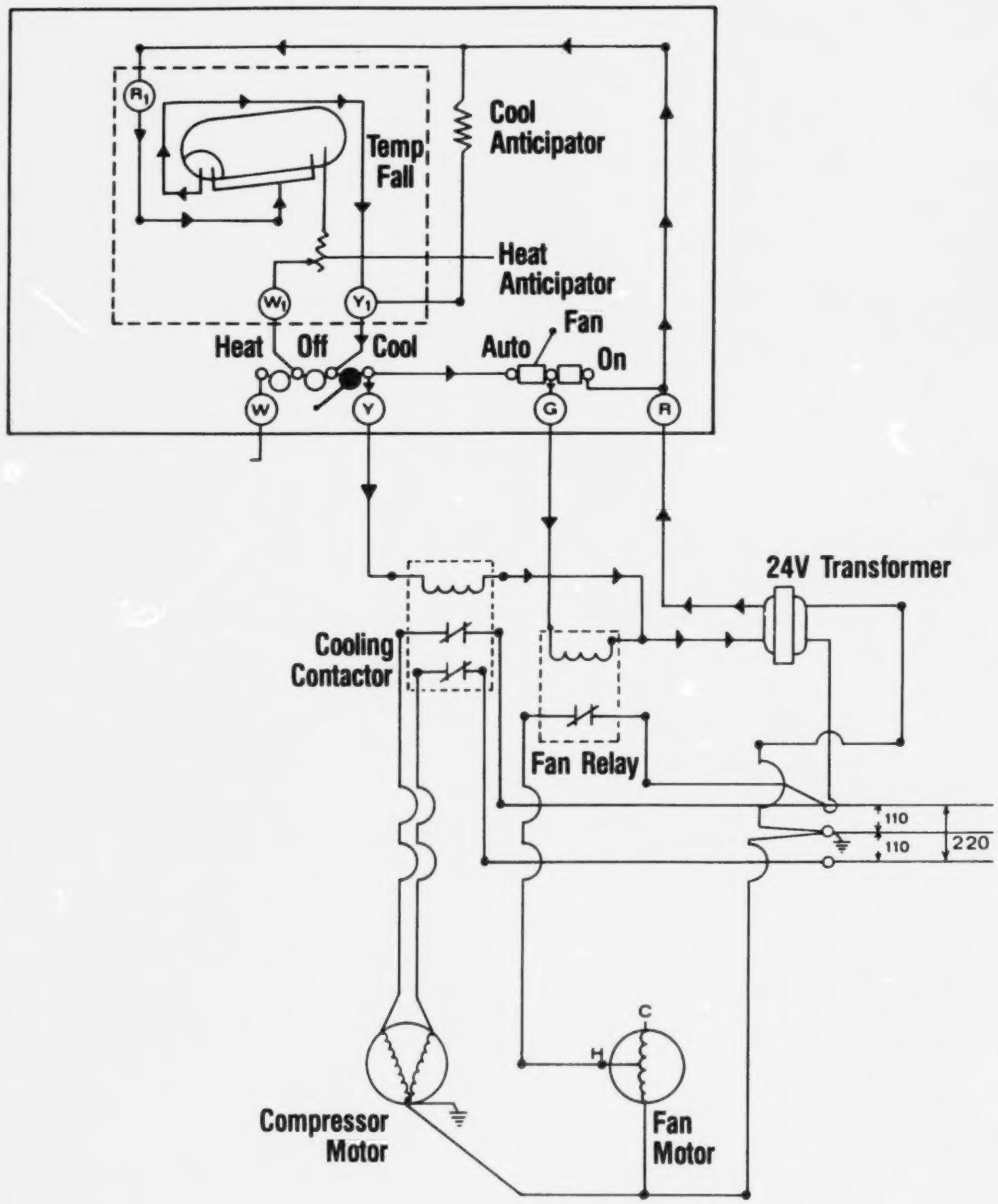

Push-Pull Solenoid
On
Momentary
Contact Switch
Switch Leg
Off
120V
Common
24V
Low Voltage Line
120V

Thermostat: Manual Fan Control


R1
Temp Fall
Cool Anticipator
Heat Anticipator
W1
Y1
Heat
Off
Cool
Auto
Fan
On
W
Y
G
R
24V Transformer
Fan Relay
110
110
220
C
H
Fan Motor

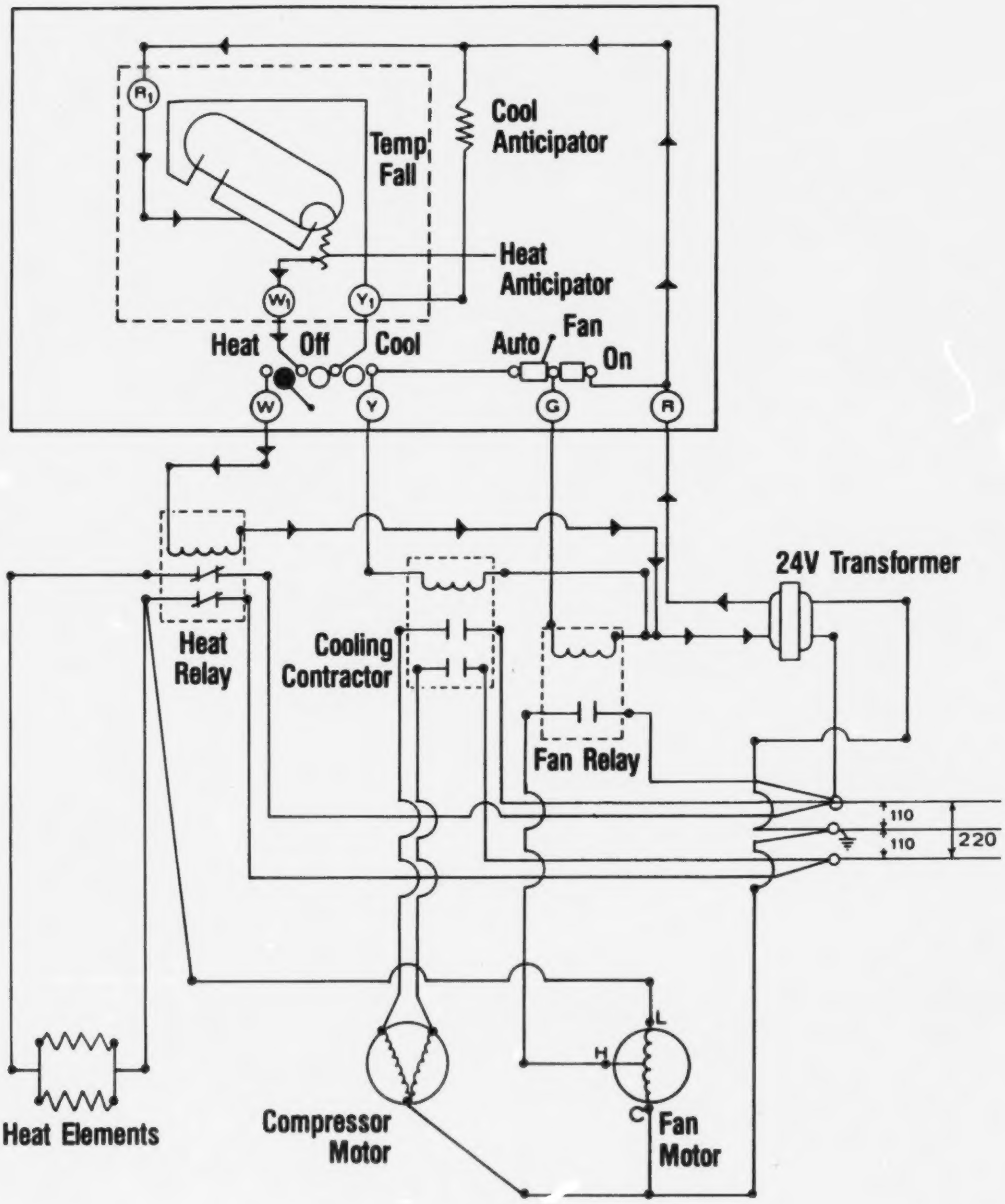
828

Thermostat: Cooling Circuit with Automatic Fan Control


R1
Temp Fall
Cool Anticipator
Heat Anticipator
W1
Y1
Heat
Off
Cool
Auto
Fan
On
W
Y
G
R
24V Transformer
Cooling Contactor
Fan Relay
110
110
220
C
H
Compressor Motor
Fan Motor

829

Thermostat: Heating Circuit with Automatic Fan Control


R1
Temp Fall
Cool Anticipator
Heat Anticipator
W1
Y1
Heat
Off
Cool
Auto
Fan
On
W
Y
G
R
24V Transformer
Heat Relay
Cooling Contractor
Fan Relay
110
110
220
Heat Elements
Compressor Motor
H
L
C
Fan Motor

830

Low Voltage Wiring
Unit 13

Information Sheet

1. **Terms and definitions**

   a. **Coaxial cable** — Conductor used for carrying communication signals

   b. **Heat detectors** — A fire warning device commonly used in a residence; available in two types: fixed or rate-of-rise temperature detectors

   c. **Momentary contact switch** — A switch that is closed or opened only while the operator touches it

   d. **Pull-push solenoid** — Solenoid with two electromagnetic circuits that will pull or push a plunger depending on which magnet has circuits applied to it

   e. **Relay** — Electromagnetic device for remote or automatic control

   f. **Smoke detector** — A fire warning device commonly used in a residence; available in two types: photoelectric or ionization

   g. **Solenoid** — Electromagnetic cylinder that moves an iron plunger when current is applied

   h. **Telephone system** — A personal communication system installed in the home to provide outside conversation with the world

   i. **Thermostat** — A device that senses temperature variations from a set point and, in turn, acts to control a circuit

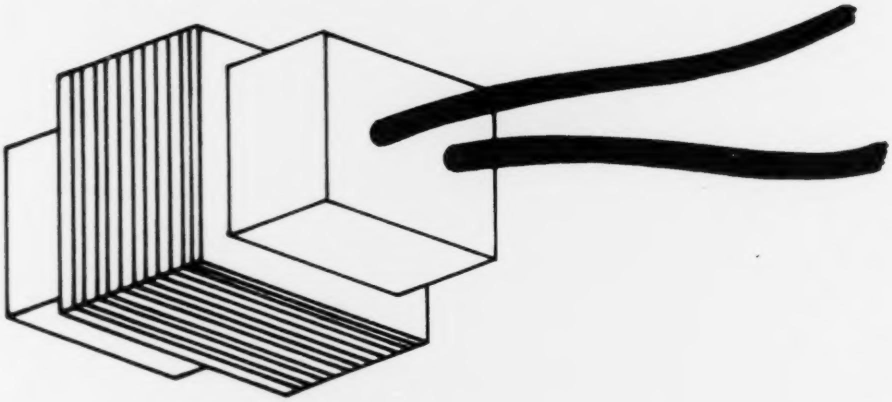
   j. **Transformer** — An electrical device used to step up or step down a primary voltage to a desired secondary voltage

Information Sheet

2. **Parts of a low voltage wiring system** (Figures 1-4)

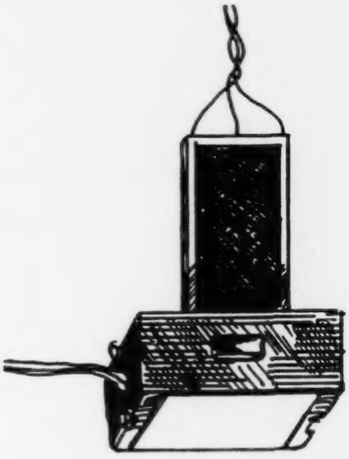
   a. 24-volt transformer

   Figure 1



   b. Low voltage lighting relay

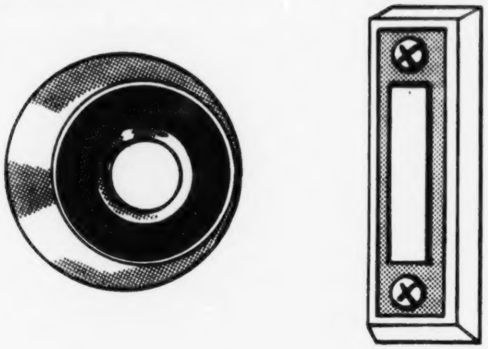
   Figure 2



Information Sheet

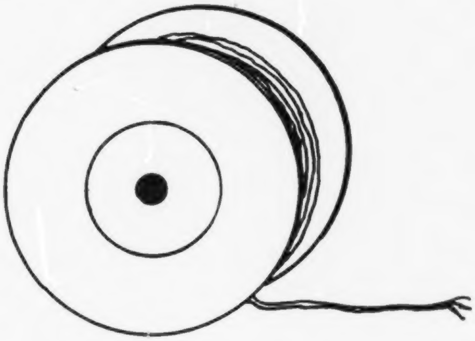
c. Momentary contact switch

Figure 3



d. Low voltage cable

Figure 4

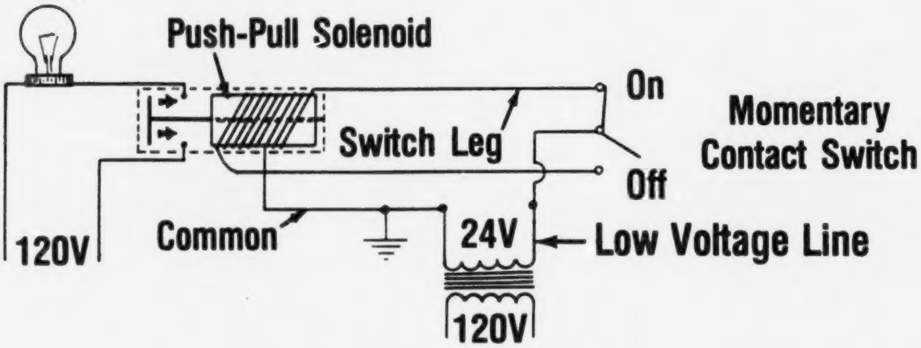


Information Sheet

3. **Low voltage lighting circuit off/on cycle** (Figures 5-7)

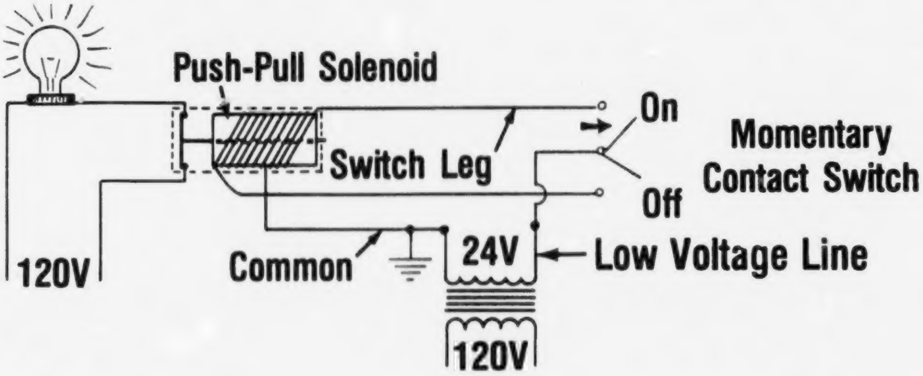
   a. "On" switch is pushed. (Figure 5)

Figure 5


Push-Pull Solenoid
On
Momentary
Contact Switch
Switch Leg
Off
120V
Common
24V
Low Voltage Line
120V

- Circuit is completed to closing movement of solenoid in relay. (Figure 6)
- Core is moved and circuit is completed.

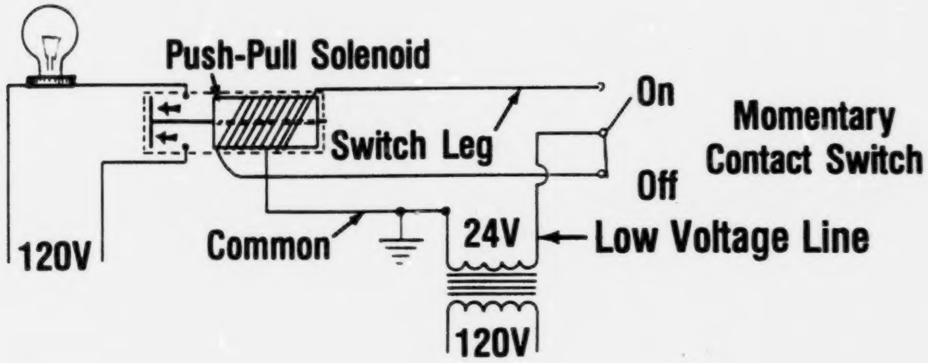
Figure 6


Push-Pull Solenoid
On
Momentary
Contact Switch
Switch Leg
Off
120V
Common
24V
Low Voltage Line
120V

Information Sheet

b. "Off" switch is pushed.

- Circuit is completed to opening movement of solenoid in relay. (Figure 7)
- Core is moved and circuit is opened.


Push-Pull Solenoid
On
Momentary Contact Switch
Switch Leg
Off
Common
24V
Low Voltage Line
120V
120V

4. **Process that takes place curing the energizing of a chime circuit**

Note: This is a front door signal on a two-note chime.

a. Button is pushed.

- Circuit is completed to solenoid.
- Plunger is drawn down to chime and sound is made.

b. Button is released.

- Circuit is open.
- Spring pulls plunger up to upper chime and another sound is made.

Information Sheet

5. **Manual fan switching circuit** (Figure 8)

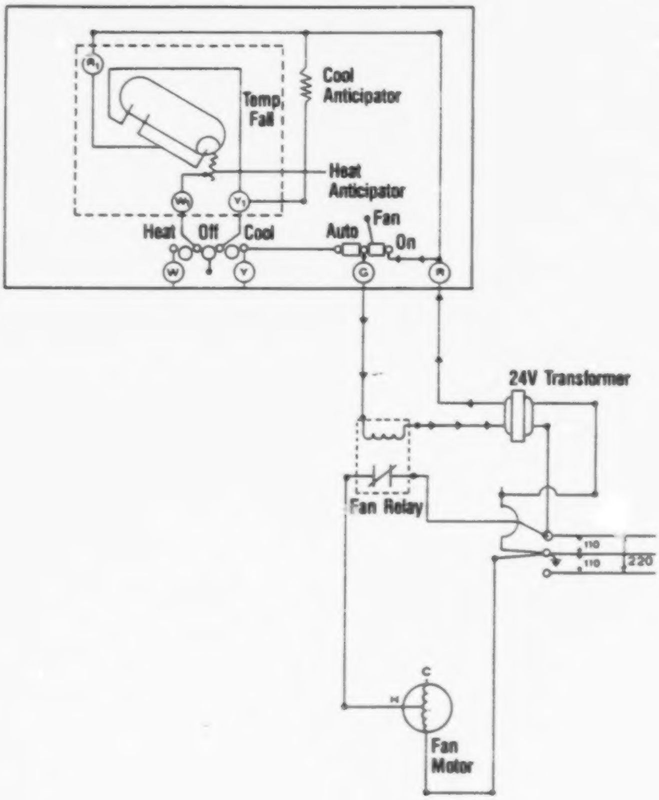
   a. Current from transformer goes to fan control switch.

   b. Closed switch directs current to fan relay control coil.

   Note: This closes normally open contacts, and the fan motor receives line voltage and runs.

   c. Common conductor returns current to transformer.

Figure 8


R1
Temp. Fall
Cool Anticipator
Heat Anticipator
W1
Y1
Heat
Off
Cool
Auto
Fan
On
W
Y
G
R
24V Transformer
Fan Relay
110
110
220
C
H
Fan Motor

Information Sheet

6. **Thermostat system switch in cool position, fan switch on auto** (Figures 9 and 10)

   a. Current from transformer goes to mercury bulb switch.

   b. From mercury switch current goes to the system switch.

   c. Current splits at the system switch.

   - One split goes to fan switch.

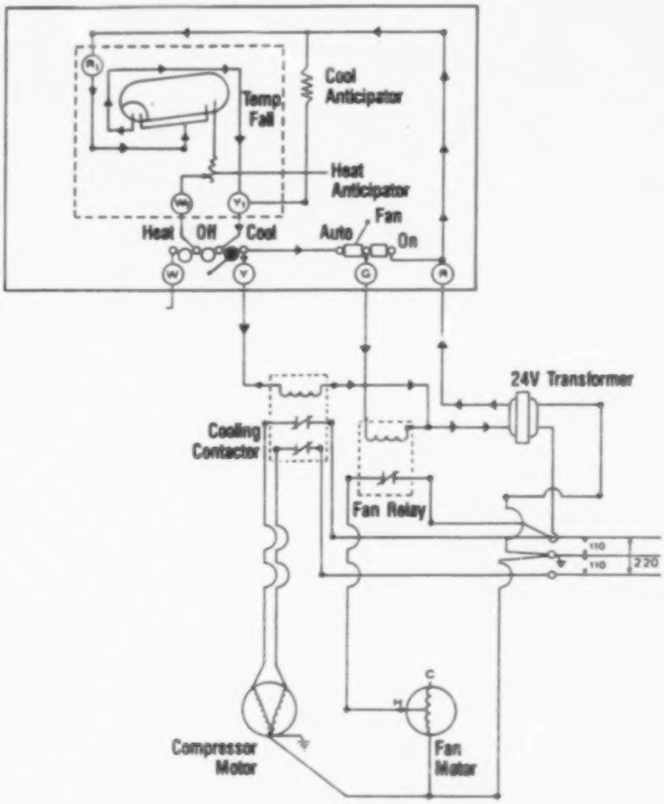
     Note: Follow the arrow heads.

     — Through closed automatic contacts
     — To fan relay control coil

       Note: This closes normally open relay contacts and starts fan motor.

     — Back to transformer

Figure 9

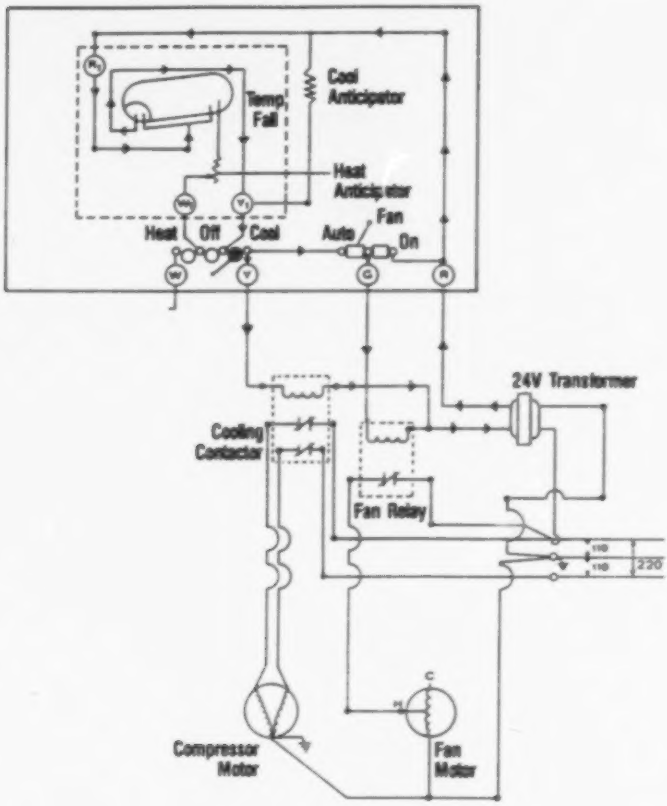

R1
Temp. Fall
Cool Anticipator
Heat Anticipator
W1
Y1
Heat
Off
Cool
Auto
Fan
On
W
Y
G
R
24V Transformer
Cooling Contactor
Fan Relay
110
110
220
C
H
Compressor Motor
Fan Motor

Information Sheet

- One split goes to the cooling contactor.
  - — Through cooling contactor coil

    Note: This closes normally open contacts and compressor starts.
  - — Back to transformer

Figure 10


R1
Temp. Fall
Cool Anticipator
Heat Anticipator
W1
Y1
Heat
Off
Cool
Auto
Fan
On
W
Y
G
R
24V Transformer
Cooling Contactor
Fan Relay
110
110
220
C
H
Compressor Motor
Fan Motor

Information Sheet

7. **System switch in heat position** (Figure 11)

   a. Current from transformer goes to mercury bulb switch,

   b. Through mercury bulb switch to system switch,

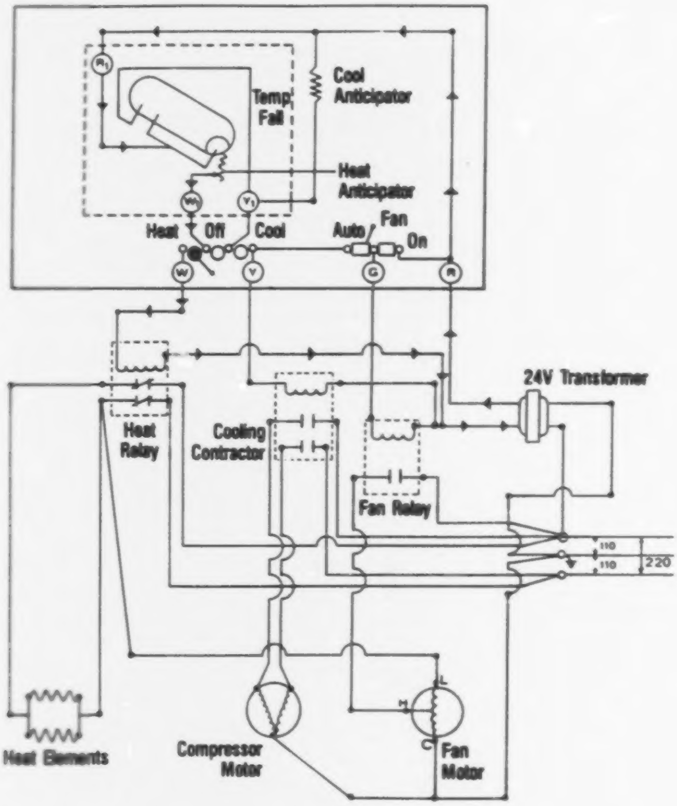
   c. Through closed contacts of heat circuit,

   d. To heating contactor or control valve coil, and

   Note: This closes normally open relay contacts and energizes elements and low-speed fan control. On gas models, a plenum switch energizes the fan motor.

   e. Back to transformer.

Figure 11


R1
Temp Fall
Cool Anticipator
Heat Anticipator
W1
Y1
Heat
Off
Cool
Auto
Fan
On
W
Y
G
R
24V Transformer
Heat Relay
Cooling Contractor
Fan Relay
110
110
220
Heat Elements
Compressor Motor
L
M
C
Fan Motor

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Information Sheet

8. **Anticipator circuits on low voltage thermostats** (Figure 12)

    a. Heat and cool anticipators are installed to compensate for bimetallic lag.

    b. Cool anticipator

    Note: These are usually fixed resistors.

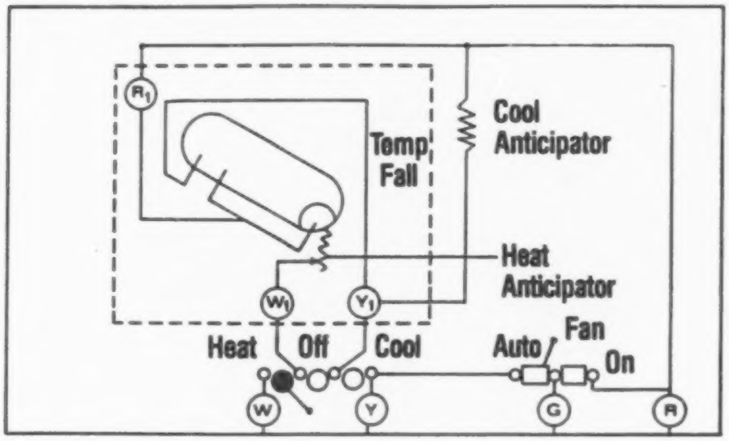
    - It is wired parallel to mercury switch.
    - Current draw through the resistor causes heat.
    - Heat causes bimetal to tilt bulb and close circuit before room temperature actually reaches "on" temperature setting.

    c. Heat anticipator

    Note: These are usually variable resistors.

    - It is wired in series with mercury switch.
    - Current draw through switch causes heat.
    - Heat causes bimetal to tilt bulb and open circuit before room temperature reaches desired room setting.

Figure 12


R1
Temp Fall
Cool Anticipator
Heat Anticipator
W1
Y1
Heat
Off
Cool
Auto
Fan
On
W
Y
G
R

Information Sheet

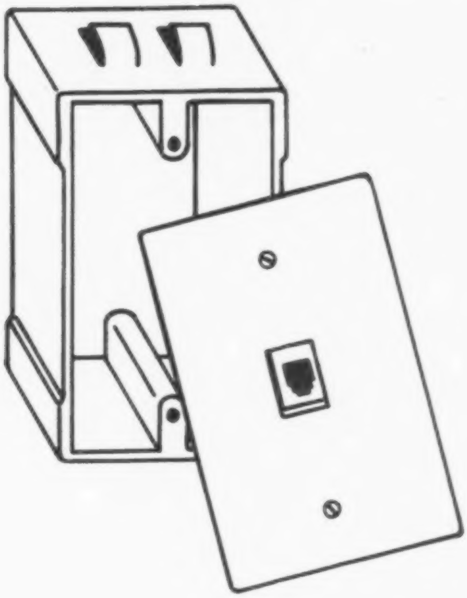
9. **Communication circuits and their characteristics** (Figures 13 and 14)

Note: All equipment must be UL listed.

a. Telephone

- The point where the local telephone's wiring ends and the home owner's interior wiring begins is called the "demarkation point."
- The telephone wiring inside the home must comply to the rules in Article #800 of the *NEC*.
- The most common telephone wiring for a new home or existing home extensions is 4-conductor #22 or #24 cable.
- The common terms for telephone cable is: two pair—4 conductors, three pair—6 conductors, twelve pair—24 conductors, etc.
- Telephone circuits require a separate pair of conductors from the telephone all the way back to the phone company's switching center.
- For new construction installations, standard electrical boxes are used at telephone outlet locations. These boxes will support wall phones or modular plates.

Figure 13



Information Sheet

- The two types of standard telephone wiring methods are individual cables run to each telephone outlet or a complete loop system.

  Note: With the loop system, should anything happen to one section of the cable, the circuit can be fed from the other direction.

- All telephone hook-ups are wired in a parallel pattern.

  Note: *NEC*, Art. 800 covers installation requirements for phone systems. Local telephone companies may also have additional requirements. There is little danger of electrical shock from the telephone's own voltage when the phone is not ringing (only 48-volt DC is present). The operation of the phone signaling device (ringing) requires 85- to 90-volt AC. This voltage is supplied by the telephone company. If contact is made with this higher AC voltage, it can be uncomfortable but not harmful. To avoid electrical shock, take the receiver off the hook when working on the system.

b. Intercom system

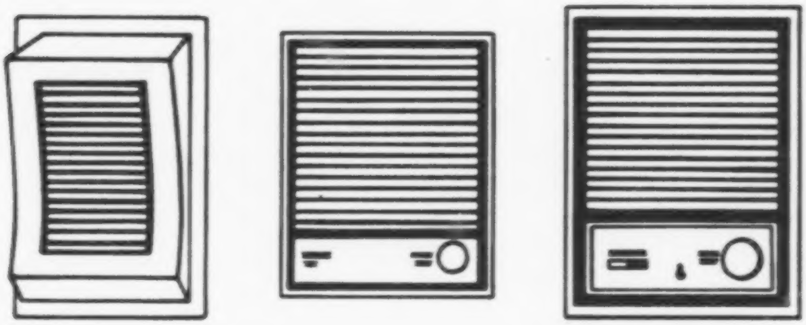
- This low voltage wiring system allows one-way monitoring or two-way conversation communication throughout the residence.

- Most systems today also incorporate radio and tape through the system speakers.

- The system also provides added security with door answering communication without opening your door to a stranger.

  Note: Shown below are typical system components.

Figure 14



Information Sheet

c. Television antenna

- The television antenna and Community Antenna Television (CATV or Cable) system installed in the home is regulated by Art. 820 of the *NEC*.
- Television cable is available in two basic types: twin lead (300 ohms) and coaxial (75 ohms).
- All television cable systems must be grounded.
- If a separate grounding electrode is used, other than a service grounding electrode, the two electrodes must be bonded.

10. Smoke and fire alarm systems

Note: *NEC* Article 760.53 pertains to requirements for fire protection signalling systems.

a. Heat and smoke detectors installed in a residence give people early warning of the presence of fire.

Note: Fire is the third leading cause of accidental fatalities. Home fires account for the biggest share of the deaths; most occur at night when people are asleep. Heat and smoke detectors are available in single or multi-installation types.

b. Two types of fire warning devices commonly used in residences are heat detectors and a smoke detectors.

c. Heat detectors sense a specific fixed temperature, such as 135°F or 200°F, or a rate-of-rise (12 to 15 degrees per minute), such as rises caused by flash fires.

d. The two most common types of smoke detectors are:

- **Photoelectric** — This detector has a light sensor that measures the amount of light in a chamber. Smoke reduces the amount of light and an alarm is sounded.

  Note: This type of detector is most useful in situations where burning materials, such as rags, mattresses, and furniture create great quantities of smoke.

- **Ionization** — This detector has a source of particles that ionize the air in the chamber. Inside the chamber are two plates of opposite charge. The ionized air conducts a small current (millionths of an ampere) between the plates. Smoke entering this chamber restricts the current flow causing an alarm to sound.

  Note: This type of detector is most useful in situations where burning materials, such as gasoline or alcohol, create very small amounts of smoke.

Information Sheet

11. **Operation of a garage door opener**

   a. The opener contains a motor, gear reduction unit, motor reversing switch, transformer, and electric brake. All of the components are pre-assembled.

   b. The electrically operated reversing switch can be controlled by push-button or key operated switch stations and radio operated controllers (remote control).

   c. The push-button or key operated station consists of a normally-open momentary contact switch connected by 2-wire, low voltage cable to the control unit. Actuation of switches causes the step relay to close, energizing the motor in the opposite direction of its previous travel.

   d. The radio-controlled operator consists of a transmitter of a set frequency. The receiver on the control unit is set for the corresponding frequency so that when the receiver detects a signal of that frequency (from the remote-control device) it will energize the motor in the opposite direction of its previous travel.

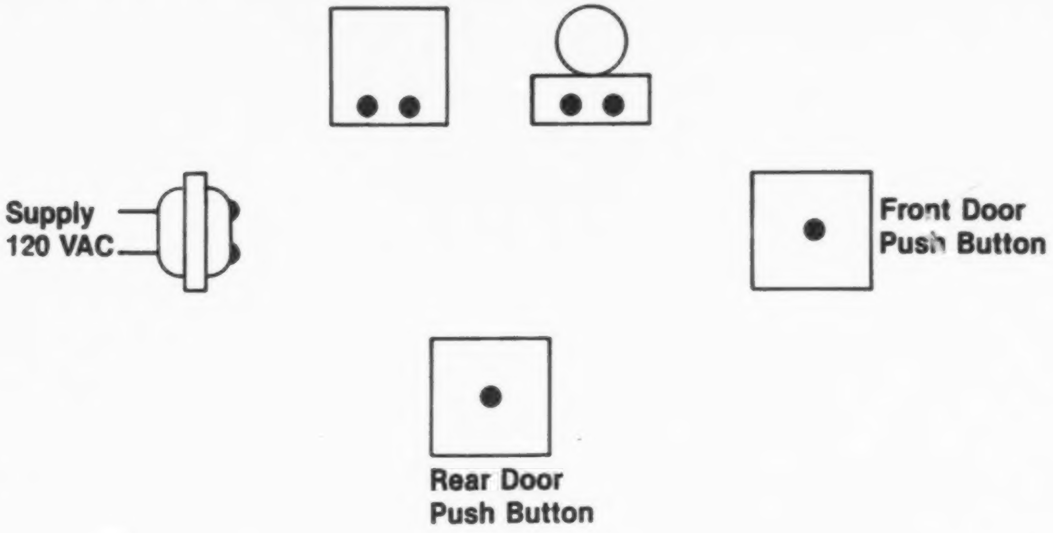
Low Voltage Wiring
Unit 13

Assignment Sheet 1—Draw a Wiring Diagram Indicating the Proper Connection for Bell Circuit Equipment

Name ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
All connections indicated	_____
Correct symbols used	_____
Circuit wiring correct configuration per answer to assignment sheet	_____

Directions: Draw a wiring diagram indicating the proper connection for the bell circuit equipment below. Make connections so that the buzzer announces the rear door and the bell rings for the front door.


Supply
120 VAC
Front Door
Push Button
Rear Door
Push Button

BW-501

Low Voltage Wiring
Unit 13

Job Sheet 1—Wire a Two Switch Low Voltage Lighting Circuit

Name ______________________________ Attempt Number __________

Date ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
Gathered and used appropriate equipment and materials	______
Performed procedure safely	______
Performed all steps in procedure	______
Performed steps in correct sequence	______
Cleaned work area	______

A. Equipment and materials

120-24-volt step down transformer
One 24-volt lighting relay
Two low voltage lighting switches
One octagon box and hanger
Two single-gang plaster rings or two regular device boxes
3-wire low voltage cable
12-2G or 14-2G NM cable
Wire connectors
Light socket
Incandescent bulb
Staples
Stud wall or shop board
Fasteners (nails or screws) to secure boxes and hanger bar

Electrician's hammer
Flat-blade screwdriver
Lineman's pliers
Long-nose pliers
Knife
Wire strippers
Drill motor and bit or brace
Extension cord if a drill motor is used.
½-inch or larger wood bit
Safety glasses
Portable GFCI
120-volt power supply

Note: A breaker panel with one breaker is needed.

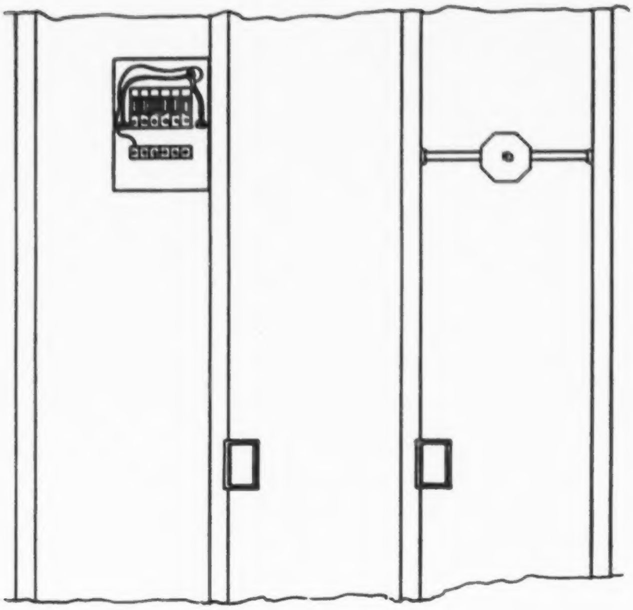
Job Sheet 1

B. Procedure

☐ 1. Put on safety glasses and gather equipment and materials.

☐ 2. Mount plaster rings, octagon box, and bar hanger. (Figure 1)

Figure 1



☐ 3. Drill holes for power and low voltage cable runs.

Note: Use your GFCI when drilling.

☐ 4. Run 120-volt supply cable from panel to lighting outlet box.

Note: In this example the transformer will be mounted at the outlet box; in a residence, it must be accessible.

☐ 5. Mount transformer on the back or top of outlet box.

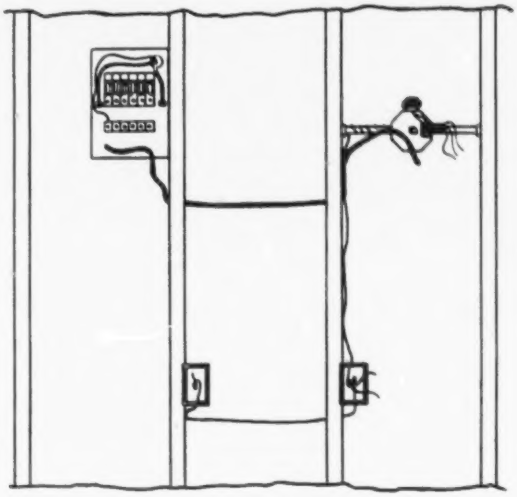
☐ 6. Install lighting relay.

Job Sheet 1

☐ 7. Run low voltage cable. (Figure 2)

Note: Wrap the cable around the bar hanger.

Figure 2

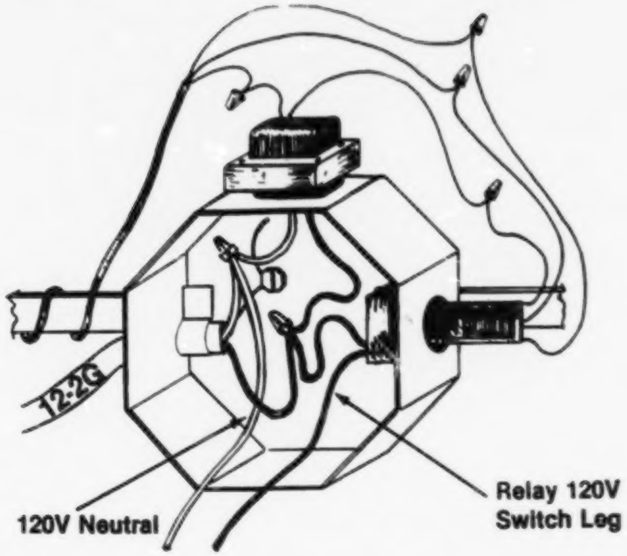


☐ 8. Make transformer and solenoid connections. (Figure 3)

Note: One transformer lead is the low voltage line, and one transformer lead goes to relay common. The remaining two relay leads should be labeled as off and on return legs for switch connections.

Job Sheet 1

Figure 3


12-2G
120V Neutral
Relay 120V
Switch Leg

☐ 9. Connect switch leg to common on both switches.

Note: A pigtail is needed on the first connection to carry the switch leg to the second switch.

☐ 10. Connect on and off return legs to appropriate switch terminals.

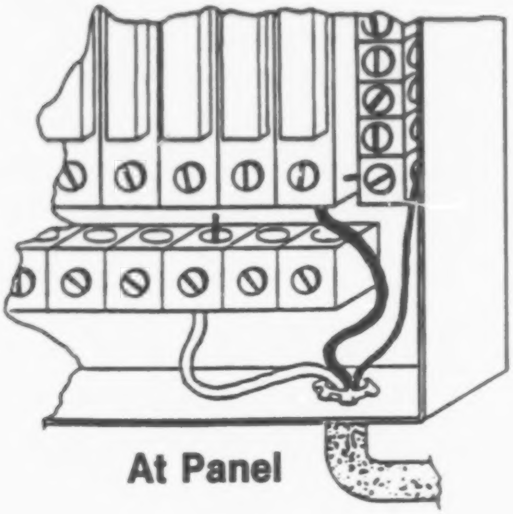
☐ 11. Mount switches.

☐ 12. Attach socket to neutral, and relay 120-volt switch leg.

Job Sheet 1

☐ 13. Make up panel. (Figure 4)

Figure 4



☐ 14. Turn on breaker.

☐ 15. Turn on at one switch and off at the other.

☐ 16. Turn on at other switch and off at the other.

Note: Have your instructor evaluate this project.

☐ 17. Turn off breaker.

☐ 18. Clean work area, and return equipment and materials to proper storage.

Evaluator's comments: ____________________

____

____

Low Voltage Wiring
Unit 13

Job Sheet 2—Wire a Two-Button Chime Circuit

Name ____________________ Attempt Number ________

Date ____________________ Overall Rating ________

Evaluation criteria	**Rating**
Gathered and used appropriate equipment and materials	______
Performed procedure safely	______
Performed all steps in procedure	______
Performed steps in correct sequence	______
Cleaned work area	______

A. Equipment and materials

Two door bell buttons
18-3 and 18-2 bell wire cable
16-volt transformer
Chime with front and back call
12-2G or 14-2G NM cable
Electrician's hammer
Long-nose pliers
Flat-blade screwdriver
Cable staples
⅜-inch cable clamp
Stud wall or shop board
120-volt power supply
Pocket knife
Wire strippers
Wire connectors
Octagon box and blank plate with ½-inch KO
¾-inch #10 metal tapping screws
Drill motor and bit or brace
½-inch or larger wood bit
Extension cord
Header board (short piece of 1″ × 6″ or 2″ × 4″)
Four 16-penny nails
Safety glasses
GFCI

Job Sheet 2

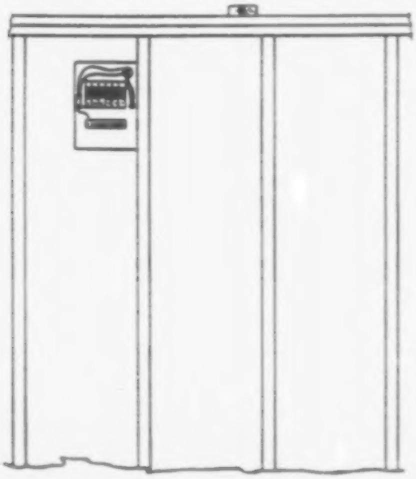
B. Procedures

☐ 1. Put on safety glasses and gather equipment and materials.

☐ 2. Mount box. (Figure 1)

Note: If mounted on a wall plate this box must be above insulation. The best place to mount the transformer is a furnace closet so you can change it without going into the attic.

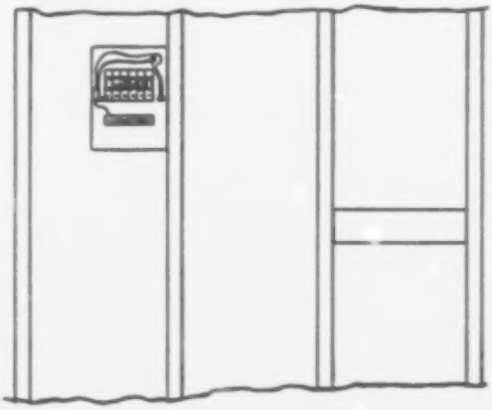
Figure 1



☐ 3. Mount header. (Figure 2)

Note: It must be mounted flush with wall surface.

Figure 2

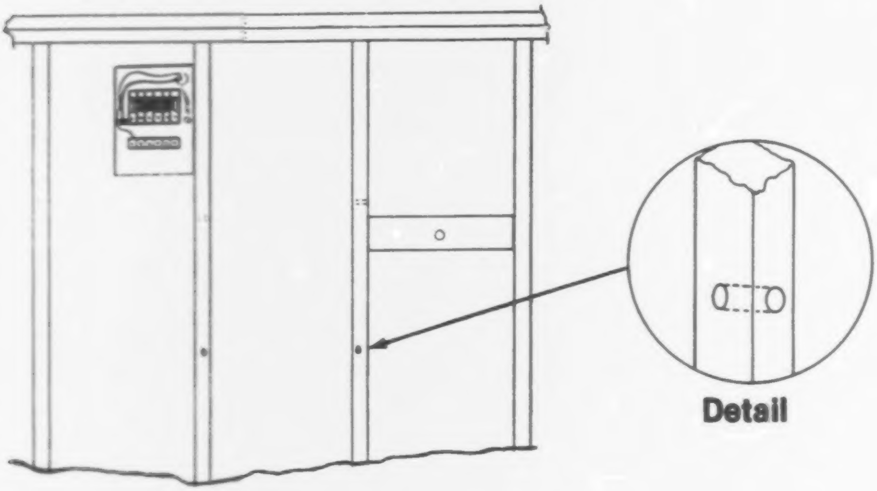


Job Sheet 2

☐ 4. Drill holes. (Figure 3)

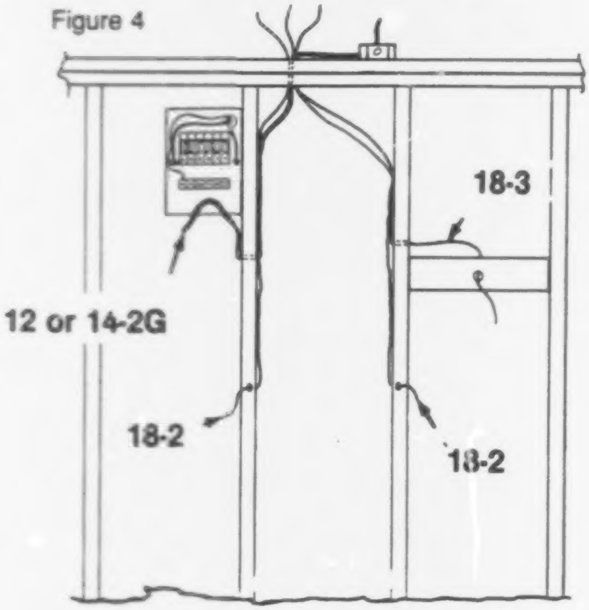
Note: On a residential rough-in, button wires are drilled through at an angle in the door opening. Use GFCI when drilling.

Figure 3



☐ 5. Run cable. (Figure 4)

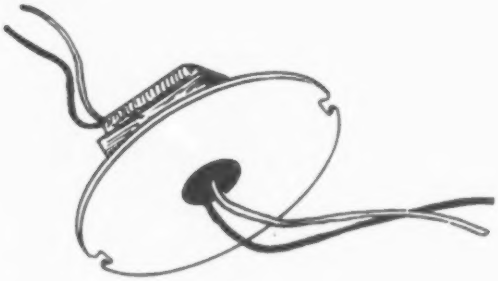
Figure 4


18-3
12 or 14-2G
18-2
18-2

Job Sheet 2

☐ 6. Mount transformer to blank plate. (Figure 5)

Figure 5

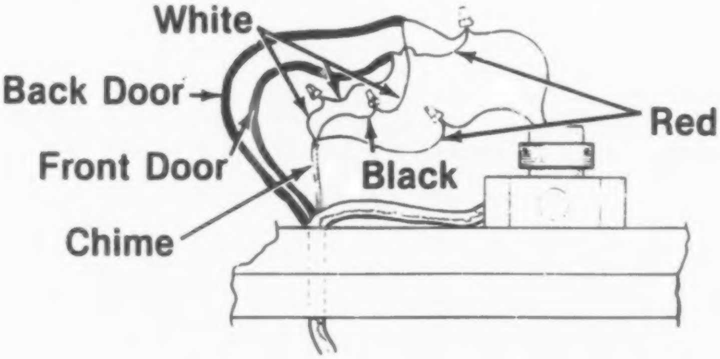


☐ 7. Connect transformer supply leads to cable from panel.

☐ 8. Mount blank plate on octagon box.

☐ 9. Make low voltage connections at transformer. (Figure 6)

Figure 6


White
Back Door
Red
Front Door
Black
Chime

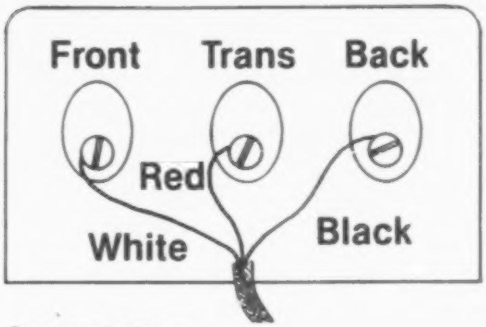
☐ 10. Mount chime on header.

Note: Put cable through opening in subbase before securing chime.

Job Sheet 2

☐ 11. Connect conductors to chime. (Figure 7)

Figure 7



☐ 12. Connect buttons.

☐ 13. Connect conductors at panel.

☐ 14. Turn on breaker.

☐ 15. Push front button.

Note: A two-tone chime should be heard.

☐ 16. Push back button.

Note: A one-tone chime should be heard. Have instructor evaluate work.

☐ 17. Turn off breaker.

☐ 18. Clean work area, and return equipment and materials to proper storage.

Evaluator's comments: ____________________

____

____

Low Voltage Wiring
Unit 13

Job Sheet 3—Determine Heat Anticipator Current Draw

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation criteria	**Rating**
Gathered and used appropriate equipment and materials	______
Performed procedure safely	______
Performed all steps in procedure	______
Performed steps in correct sequence	______
Cleaned work area	______

A. Equipment and materials

Ammeter
Coil of wire—10 loops
Heating unit with 24-volt control
Flat-blade screwdriver
Safety glasses

Job Sheet 3

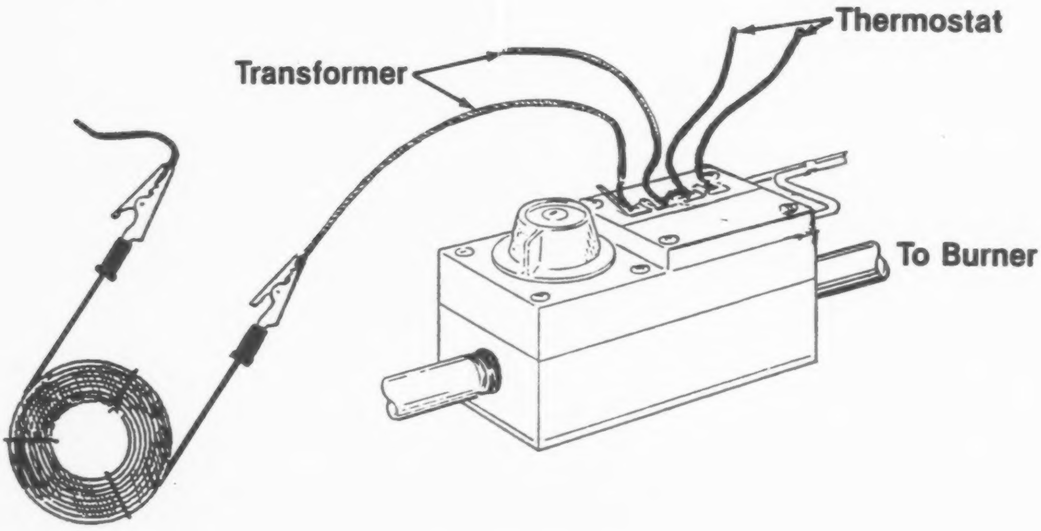
B. Procedure

☐ 1. Disconnect power from heater.

☐ 2. Place coil of wire in series with one side of heating control. (Figure 1)

Note: This may be either a gas valve or an electric relay.

Figure 1


Thermostat
Transformer
To Burner

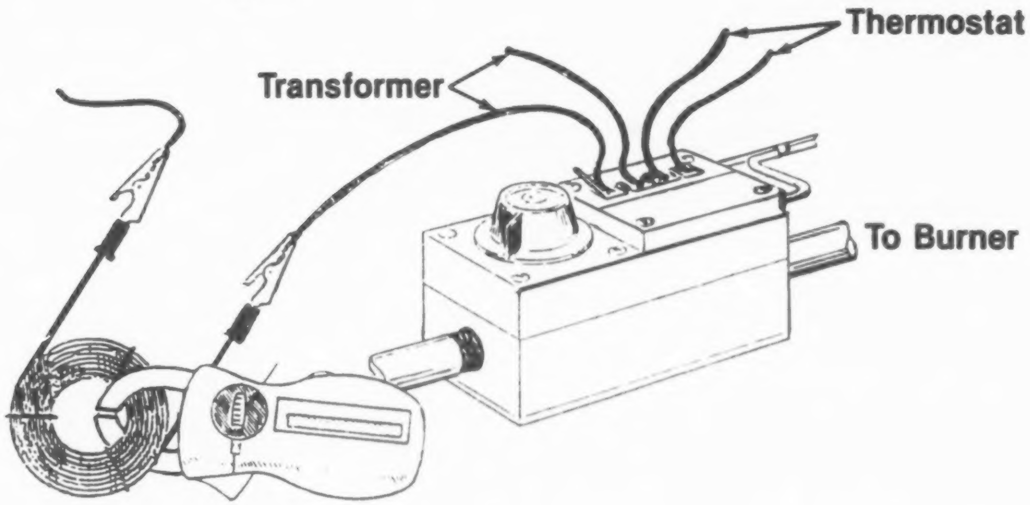
☐ 3. Turn on power.

☐ 4. Increase thermostat setting above the ambient (room) temperature.

Job Sheet 3

☐ 5. Clamp ammeter through the coil of wire. (Figure 2)

Figure 2


Thermostat
Transformer
To Burner

☐ 6. Take ammeter reading.

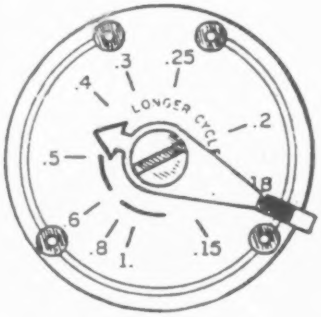
☐ 7. Divide the reading by ten to find the anticipator setting.

Example: Ammeter reading = 4
4 ÷ 10 = .4
.4 = anticipator setting

☐ 8. Set heat anticipator on thermostat. (Figure 3)

Note: Most manufacturers of heating controls will print the ampere draw of the control on the side, but in case it is not, the procedure in Step 7 may be used to determine it.

Figure 3


.3
.25
.4
LONGER CYCLE
.2
.5
.18
.6
.8
1.
.15

Job Sheet 3

☐ 9. Turn off heating unit.

☐ 10. Disconnect electrical power.

Note: Have instructor check the anticipator setting.

☐ 11. Clean work area, and return equipment and materials to proper storage.

Evaluator's comments: ____

____

____

Low Voltage Wiring
Unit 13

Job Sheet 4—Install a Wall Thermostat

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation criteria	Rating
Gathered and used appropriate equipment and materials	______
Performed procedure safely	______
Performed all steps in procedure	______
Performed steps in correct sequence	______
Cleaned work area	______

A. Equipment and materials

Flat-blade screwdriver
Scratch awl
Wire strippers
Pocket screwdriver (small-blade screwdriver)
Heat-cool thermostat subbase
Heat-cool thermostat
4-conductor thermostat wire
Torpedo level
Pencil
Safety glasses
Folding rule

B. Procedure

☐ 1. Locate area on wall for thermostat.

☐ 2. Measure up from floor 54 or 60 inches.

☐ 3. Mark a spot to center subbase.

☐ 4. Hold subbase up to wall and center it.

☐ 5. Place level on subbase.

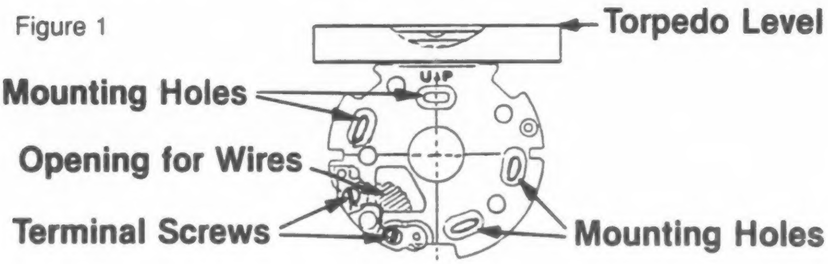
☐ 6. Check for approximate level.

Job Sheet 4

☐ 7. Mark spots for mounting screw. (Figure 1)

Note: The thermostat must be level.

Figure 1



☐ 8. Mark spots in the center of the elongated slots.

☐ 9. Move subbase.

☐ 10. Use scratch awl to make screw holes.

☐ 11. Place subbase on wall.

☐ 12. Start screws.

☐ 13. Check for level.

☐ 14. Tighten screws and recheck level.

☐ 15. Bring thermostat wire through the proper opening.

Note: Do not allow any wires to cross the center of the subbase.

☐ 16. Strip ½ inch of insulation off of each conductor.

☐ 17. Connect red wire to "R" or "V" terminal.

☐ 18. Connect white wire to "W" or "H" terminal.

☐ 19. Connect green wire to "G" or "F" terminal.

☐ 20. Connect yellow wire to "Y" or "C" terminal.

Note: Some wire manufacturers have a blue wire instead of a yellow wire in their thermostat cable.

☐ 21. Push the wires back so that they will not interfere with the thermostat.

Job Sheet 4

Note: Have instructor check work.

☐ 22. Align thermostat on subbase.

Note: To prevent cracking, be sure that thermostat is properly aligned before tightening.

☐ 23. Tighten thermostat screws.

Note: When removing a thermostat from a subbase, leave the screws in the retainers in the thermostat.

☐ 24. Place cover on thermostat.

Note: If the thermostat is on a live system turn on the power and check its operation.

☐ 25. Clean work area, and return equipment and materials to proper storage.

Evaluator's comments: ______________________________

____

____

Overcurrent Protection
Unit 14

Objective Sheet

Unit Objective

After completing this unit, the student should be able to choose and install proper overcurrent protective devices. The student should demonstrate these competencies by completing the assignment and job sheet and scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to overcurrent protection with their correct definitions.
2. List five types of overcurrent protective devices.
3. Describe the operation of a single-element fuse.
4. Describe the operation of a dual-element, time-delay fuse.
5. Distinguish between types of circuit breakers and their operation.
6. Select true statements about requirements for fuses of less than 600 volts.
7. Complete statements about requirements for circuit breakers of less than 600 volts.
8. List installations that require GFCI protection.
9. Calculate fuse sizes. (Assignment Sheet 1)
10. Test cartridge fuses. (Job Sheet 1)

Overcurrent Protection
Unit 14

Suggested Activities

Instructional Plan

Preparation

1. Read the unit carefully and plan for instruction. Study the specific objectives to determine the order in which you will present them.

2. Review Teaching Suggestions section that follows. Plan for classroom activities.

3. Plan your presentation to take advantage of student learning styles and to accommodate special needs students.

4. Make transparencies from the transparency masters included with this unit. These appear in the teacher edition only and are designed to be used with the following objectives:

   TM 1—Selective Coordination (Objective 1)
   TM 2—Fuse Elements (Objective 2)
   TM 3—Time-Current Curve Average Melt for One-Time General Purpose NON (Single-Element Fuse) (Objective 3)
   TM 4—Time-Current Curve Average Melt for Dual-Element Time-Delay FRN-R & FRS-R (Objective 3)
   TM 5—Ground Fault Relaying (Objective 8)

5. Obtain films, videotapes, and other resources to supplement instruction of this unit. See ordering information in the Suggested Supplemental Resources section that follows.

6. Develop teaching plan. Adjust for different learning styles.

7. Make copies of Unit Evaluation Form.

Delivery and Application

8. Provide students with unit of instruction.

9. Discuss unit and specific objectives.

10. Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.

11. Discuss the assignment sheet and schedule due date. Review criteria for evaluation of this activity.

12. Discuss and demonstrate the job sheet. Review criteria for evaluation of this activity.

Suggested Activities

Evaluation

13. Discuss the use of the Unit Evaluation Form with students. Discuss the rating scale that will be used for student evaluation.

14. Make copies of the written test. Add or modify test items as needed.

15. Give written test.

16. Compile assignment and job sheet ratings and written test scores on the Unit Evaluation Form. Add any additional assignments or supplemental activities that should be part of the unit evaluation.

17. Reteach and retest as required.

Teaching Suggestions

Note: Skill areas appearing in boldface type in the Teaching Suggestions refer to the academic and workplace skills identified by the American Society for Training and Development (ASTD) and the U.S. Department of Labor. These have been adapted by MAVCC.

1. Use the design plan in Teacher Supplement 1 to construct a display to demonstrate the need for proper overcurrent protection.

2. Invite a Buss fuse representative to speak to the class. Skill area: **Listening**

3. Show cutaways of each type of breaker and fuse. Skill area: **Observing application of scientific principles**

4. Arrange a field trip to a local electrical supply house to view varied types of overcurrent protective devices.

Resources Used in Developing This Unit

1. *Buss Full Line Catalog (FLC).* Bussmann Division, McGraw-Edison Co., 1985.

2. *Maintenance of Low Voltage Circuit Breakers and Switch Gear.* Rockville, MD: NUS Training Corporation, a Halliburton Company.

3. Earley, Mark W., John M. Caloggero, and Richard H. Murray. *National Electrical Code 1993.* Quincy, MA: National Fire Protection Association, 1992.

Suggested Activities

4. Stallcup, James G. *Illustrated Changes of the 1993 NEC.* Homewood, IL: American Technical Publishers, Inc., 1992.

5. Taylor, Mark. *Residential Wiring.* Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1983.

6. Teague, Cash and Garner Pewewardy. *Industrial Electricity: In-Plant Distribution.* Stillwater, OK: Oklahoma Curriculum and Instructional Materials Center, 1984.

Instructions for Evaluating Student Performance

Assignment Sheets—Be sure the student understands the criteria on which the evaluation is based. Assign a point value to each criterion and convert the total points to a percentage for grading.

Job Sheets—Be sure the student understands the criteria on which the evaluation is based. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in either the teacher edition or student manual. Then observe the student performing the procedure. Rate both process and product.

> Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily achieved the step(s) for each checkpoint area. If the student is unable to correctly complete the procedure, have the student review the materials and try again.
>
> Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria which have been provided as part of the job sheet. Complete the rating by assigning a point value to each criterion and by converting the point total to a percentage for grading. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) which best fits your program needs.

Option A

4 - Skilled—Can perform job with no additional training.
3 - Moderately skilled—Has performed job during training program; limited additional training may be required.
2 - Limited skill—Has performed job during training program; additional training is required to develop skill.
1 - Unskilled—Is familiar with process, but is unable to perform job.

Option B

Yes—Can perform job with no additional training.

No—Is unable to perform job satisfactorily.

Overcurrent Protection
Unit 14

Answers to Assignment Sheet 1

A. FLC = 10.6 x 1.25 = 13.25 Amps
Fuse = 15 Amp Conductor = 14 AWG, THWN

B. FLC = 16.7 x 1.15 = 19.2 Amps
Fuse = 20 Amp Conductor = 12 AWG, THHN

C. FLC = 10.6 x 1.15 = 12.19 Amps
Fuse = 15 Amp Conductor = 14 AWG, THW

D. FLC = 30.8 x 1.25 = 38.5 Amps
Fuse = 40 Amp Conductor = 8 AWG, THHN

E. FLC = 24.2 x 1.15 = 27.83 Amps
Fuse = 30 Amp Conductor = 10 AWG, THWN

F. FLC = 59.4 x 1.25 = 74.25 Amps
Fuse = 80 Amp Conductor = 4 AWG, THWN

G. M6 = 59.4 x 1.50 = 89.1
M5 = 24.2 x 1.0 = 24.2
M4 = 30.8 x 1.0 = 30.8
M3 = 10.6 x 1.0 = 10.6
M2 = 16.7 x 1.0 = 16.7
M1 = 10.6 x 1.0 = 10.6
Total 182.0 Amps

Fuse = 200 Amp Conductor = 3/0 AWG, THW

H. 20 x 1.25 = 25 Amps
Fuse = 25 Amp Conductor = 10 AWG, THWN

I. 40 x 1.0 = 40 Amps
Fuse = 40 Amp Conductor = 8 AWG, THHN

J. 60 x 1.25 = 75 Amps
Fuse = 80 Amp Conductor = 6 AWG, Z

K. 60 x 1.25 = 75
40 x 1.00 = 40
25 x 1.00 = 25
Total 140 Amps

Fuse = 150 Amp Conductor = 1 AWG, THHN

Answers to Assignment Sheet 1

L. 40 x 1.25 = 50 Amps
Fuse = 50 Amp Conductor = 8 AWG, THHN

M. 13.2 x 1.15 = 15.23 Amps
Fuse = 15 Amp Conductor = 14 AWG, THHN

N. 13.2 x 1.50 = 19.8
40 x 1.25 = 50
Total 69.8 Amps

Fuse = 70 Amp Conductor = 6 AWG, THHN

O. 50 x 1.00 = 50 Amps
Fuse = 50 Amp Conductor = 8 AWG, THW

P. Largest Motor = 89.1 x 1.50 = 133.65

All other Motors = 10.6
30.8
24.2
+ 13.2
Total = 78.8 x 1.00 = 78.80

Continious Load = 10.6
16.7
20.0
60.0
+ 40.0
Total = 147.0 x 1.25 = 184.13

Non-continious
Load = 40
+ 50
Total = 90 x 1.00 = 90

Total Connected Load = 468.58 Amps

Fuse = 500 Amp Conductor = 700 kcmil, THWN

Overcurrent Protection
Unit 14

Answers to Written Test

1.	a.	11	f.	19	k.	5	p.	8	u.	14
	b.	22	g.	7	l.	4	q.	9	v.	15
	c.	18	h.	17	m.	21	r.	10		
	d.	16	i.	2	n.	3	s.	12		
	e.	20	j.	1	o.	6	t.	13		

2. a. Edison-base plug fuse
   b. Type "S" plug fuse (fustat)
   c. Ferrule-type cartridge fuse
   d. Blade-type cartridge fuse
   e. Circuit breaker

3. Under sustained overload conditions, the restricted portions of the fuse element heat to their predetermined melting point, thus opening and interrupting the flow of current.

4. Under sustained overload conditions, the trigger spring fractures the fusing alloy and releases the "S" connector.

5. b

6. b, d, e, g

7. a. Tripped, set
   b. Off, on
   c. Dismantling
   d. Durable, visible
   e. 5,000

8. Answer should include any five of the following:

   a. All 125-volt, single-phase 15- and 20-ampere receptacles that are not part of the permanent wiring on construction sites
   b. All 125-volt, single-phase 15- and 20-ampere receptacles installed in bathrooms
   c. All 125-volt, single-phase 15- and 20-ampere receptacles installed in garages
   d. All 125-volt, 15- and 20-ampere receptacles installed outdoors where there is direct grade level
   e. All 125-volt, 15- and 20-ampere receptacles in crawl spaces at or below grade level and in unfinished basements
   f. All 125-volt, 15- and 20-ampere receptacles within 6 feet of a wet bar sink or kitchen sink that serves counter top surfaces
   g. All 125-volt, 15- and 20-ampere receptacles installed in boathouses
   h. All 125-volt, 15- and 20-ampere receptacles installed in bathrooms of commercial, industrial, and all nondwelling occupancies

Answers to Written Test

i. All 125-volt, 15- and 20-ampere receptacles installed on roofs
j. Lighting fixtures and lighting outlets installed in the area extending between 5 feet and 10 feet horizontally from the inside walls of a pool, unless installed 5 feet above maximum water level and rigidly attached to structure adjacent to or enclosing the pool

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Overcurrent Protection
Unit 14

Written Test

Name ______________________________ Score ______________

1. Match terms related to overcurrent protection with their correct definitions. Write the correct numbers in the blanks.

______a. Accidental connection between an electrical circuit or equipment and the earth or some conducting body that serves in place of the earth

______b. Maximum voltage at which a device is designed to operate

______c. Larger than normal current flowing outside the normal current path

______d. Larger than normal current flowing within the normal current path

______e. Plotted curve showing how long a fuse or breaker will carry an overload before opening the circuit

______f. Fuse that contains only one element and is not designed to carry an overload

______g. Fuse that has within it a thermal cutout element with a time delay that permits momentary harmless inrush currents to flow without harming the fuse

______h. The use of interrupting devices sized and installed so that the one nearest the fault or overloaded machine will open before any of the larger upstream devices open

______i. Maximum current-carrying capacity of a device

______j. Breaker in which all parts operate in air

1. Air circuit breaker
2. Amperage rating
3. Blade-type cartridge fuse
4. Circuit breaker
5. Current-limiting overcurrent protective device
6. Device
7. Dual-element fuse
8. Edison-base plug fuse
9. Fault current
10. Ferrule-type cartridge fuse
11. Ground fault
12. Ground-fault circuit-interrupter
13. Interrupting rating
14. Oil circuit breaker
15. Overcurrent protection

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Written Test

______k. Device that, when interrupting current in its current-limiting range, reduces the short-circuit current flowing in the faulted circuit to substantially less than would otherwise flow into the fault

______l. Automatic overcurrent device that trips on overloads or shorts and is resettable

______m. Fuse with special size-limiting characteristics for each amperage range

______n. Fuse with flat contact blades on a cylindrical case

______o. Electrical equipment that carries or transfers current but does not use it

______p. Fuse with a base that fits the same socket as a regular based incandescent bulb

______q. Current that flows from one conductor to ground or another conductor because of an abnormal connection or arc between the two

______r. Fuse with metal caps on a cylindrical case

______s. Breaker designed to protect individuals and equipment by deenergizing or tripping a circuit when current to ground reaches some predetermined value that is less than that required to operate the overcurrent protective device of the supply circuit

______t. Maximum available short-circuit current that an overcurrent device can safely interrupt without damage to itself

______u. Load interrupter in which the interrupting contacts operate submerged in transformer oil

______v. Weak link in the circuit that limits the amperage to a specified amount

16. Overload
17. Selective coordination
18. Short circuit
19. Single-element fuse
20. Time-current curve
21. Type "S" plug fuse
22. Voltage rating

Written Test

2. List five types of overcurrent protective devices.

   a. ______________________________

   b. ______________________________

   c. ______________________________

   d. ______________________________

   e. ______________________________

3. Describe the operation of a single-element fuse.

   ____

   ____

   ____

4. Describe the operation of a dual-element, time-delay fuse.

   ____

   ____

   ____

5. Distinguish between types of circuit breakers and their operation. Write a "T" for thermal trip next to its correct operation.

   ______a. As current flows through the breaker, it creates a magnetic field within the coil. During sustained overload conditions, the magnetic field interferes and draws the core into the coil. The metal trip bar is attracted to the core forcing the latch to move, thus opening the contacts.

   ______b. If current flow exceeds the rated limit of the breaker, the bimetallic strip heats and bends. As the strip bends, the latching mechanism is tripped and the contacts open.

Written Test

6. Select true statements about requirements for fuses of less than 600 volts. Write an "X" in the blank before each true statement.

   ______a. Plug fuses shall be used in circuits exceeding 125 volts between conductors.

   ______b. Fuses shall be marked with their amperage rating.

   ______c. Edison-base plug fuses shall be classified 0 to 20 amperes.

   ______d. Plug fuses may be used only as replacements.

   ______e. Type "S" fuses (fustats) shall be classified at not over 125 volts.

   ______f. Different ampere classes of Type "S" fuses are interchangeable.

   ______g. Cartridge fuses shall be marked with their ampere rating, voltage rating, and the name or trademark of the manufacturer.

7. Complete the following statements about requirements for circuit breakers of less than 600 volts. Write in the blanks the word(s) that best completes each statement.

   a. Circuit breakers shall be capable of being manually ____________________ and ____________________.

   b. Circuit breakers shall have a visible ____________________ and ____________________ indication.

   c. The breaker shall be designed so that any change of its trip point (ampere rating) or time required for operation will require ____________________ or the breaking of a seal.

   d. Circuit breakers shall be marked with their ampere rating in a manner that will be ____________________ and ____________________ by removal of a trim or cover.

   e. Every circuit breaker having an interrupting rating other than ____________________ amperes shall have its interrupting rating shown on the circuit breaker.

8. List five installations that require GFCI protection.

   a. ____

   b. ____

   c. ____

   d. ____

   e. ____

***Permission to duplicate this test is granted.**

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Overcurrent Protection
Unit 14

Unit Evaluation Form

Student Name ______________________________ Unit Rating __________

Assignment Sheet 1—Calculate Fuse Sizes Rating ______

Comments: ____

____

Job Sheet 1—Test Cartridge Fuses Rating ______

Comments: ____

____

Written Test Scores

Pretest ______ Posttest ______ Other ______

Other ____

____

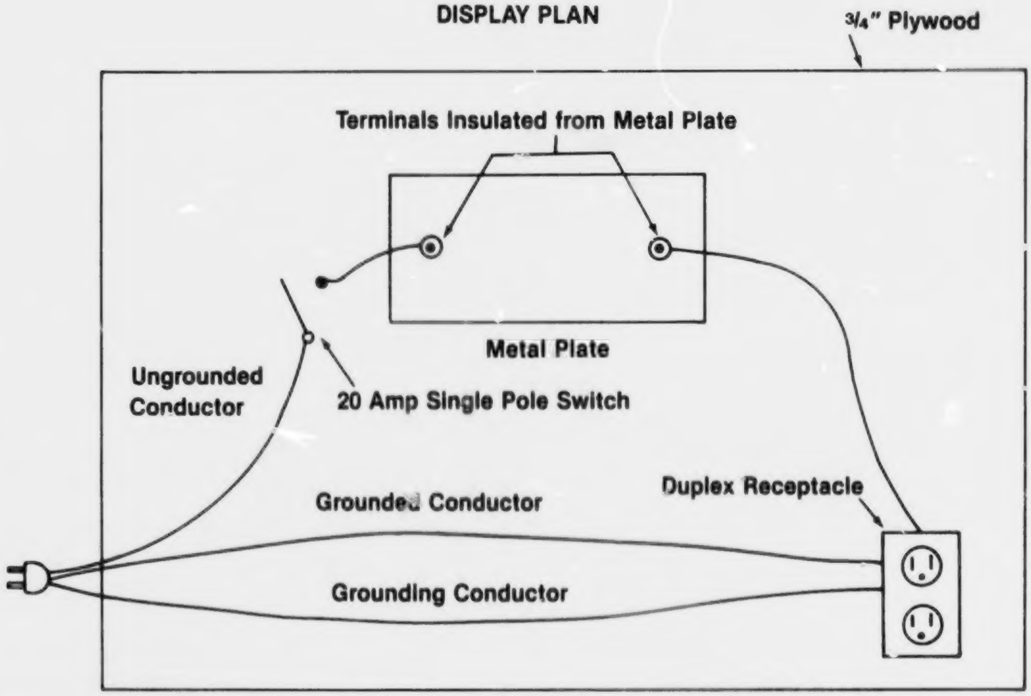
Teacher Signature ______________________________ Date __________

Student Signature ______________________________ Date __________

***Permission to duplicate this form is granted.**

Overcurrent Protection
Unit 14

Teacher Supplement 1—Design Plan for Overcurrent Protection Display


DISPLAY PLAN
3/4" Plywood
Terminals Insulated from Metal Plate
Metal Plate
Ungrounded Conductor
20 Amp Single Pole Switch
Grounded Conductor
Duplex Receptacle
Grounding Conductor

- **Place various sizes of wire between terminals starting with 12 Awg and working down.**
- **Loads can be added to the receptacle.**

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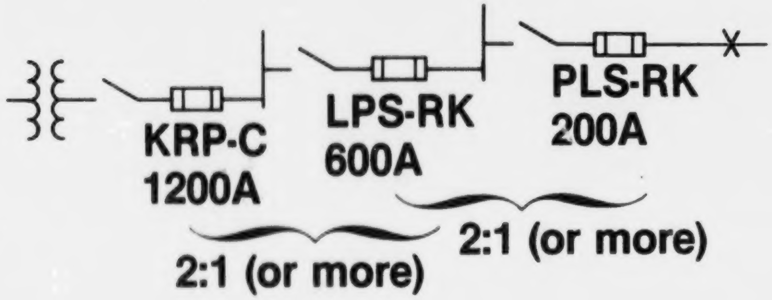
Selective Coordination



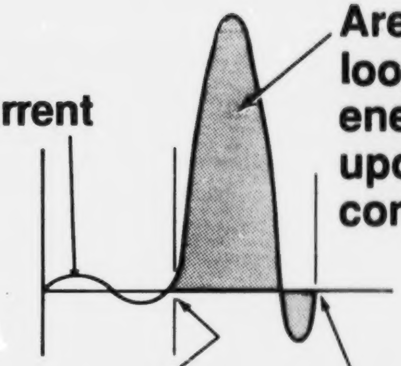
KRP-C 1200A

LPS-RK 600A

PLS-RK 200A

2:1 (or more)

2:1 (or more)

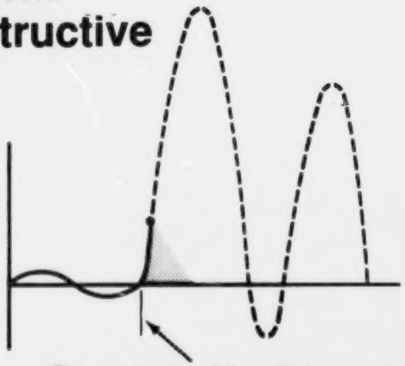


Normal Load Current

Areas within waveform loops represent destructive energy impressed upon circuit components.

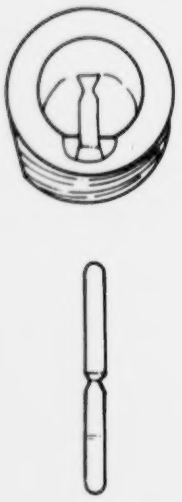
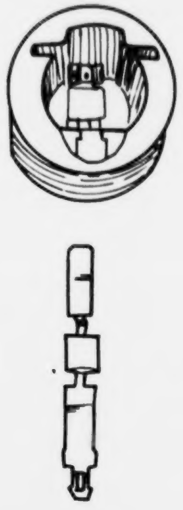
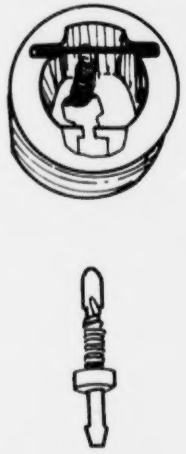
Initiation of Short-Circuit Current

Circuit breaker trips and opens short-circuit in about 1 cycle.



Current-limiting fuse opens and clears short-circuit in less than ½ cycle.

Fuse Elements

Fuse Elements			
Description	**Non-Type-Delay** Element is a simple fusible, metal link. For general purpose circuit protection. Quickly opens (blows) when short-circuit or overload occurs. Use for lighting and other non-motor circuits.	**Time Delay, Loaded Link** Heat absorbing metal bead on element link for time delay. Passes motor overload starting currents without needlessly opening.	**Time-Delay, Dual-Element** For all-purpose application. Like two fuses in one. A simple link element for short-circuits and dangerous overloads plus a series-connected element which lets the harmless overload starting currents of motors pass without opening. Uses less energy, operates cooler, provides superior protection.

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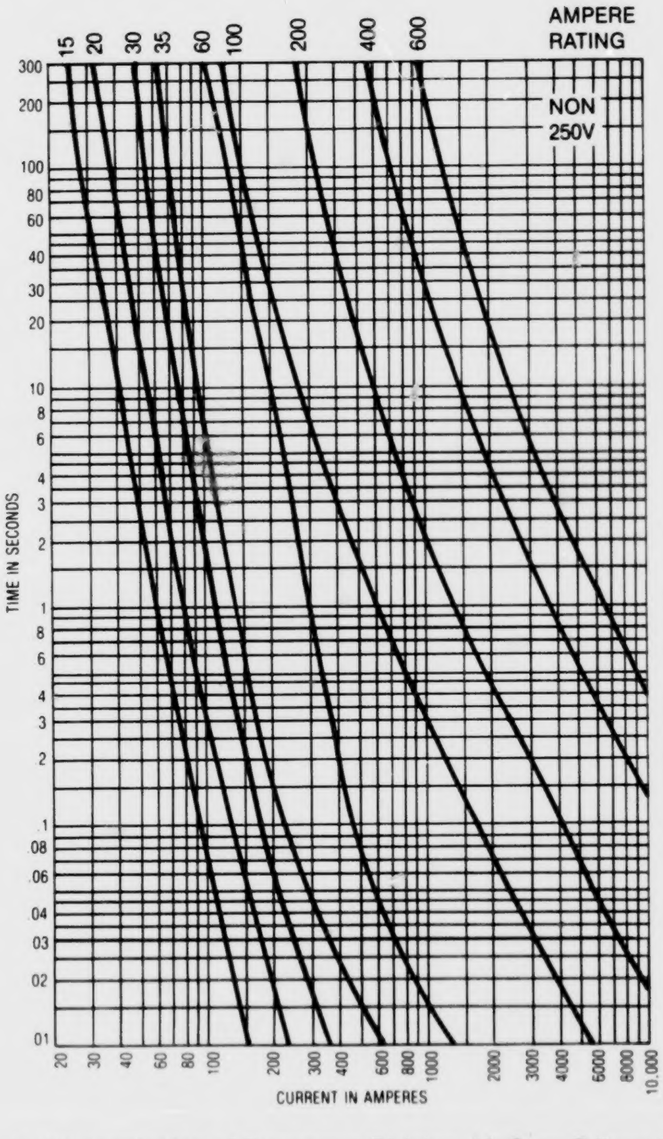
Time-Current Curve Average Melt for One-Time General Purpose
NON
(Single-Element Fuse)



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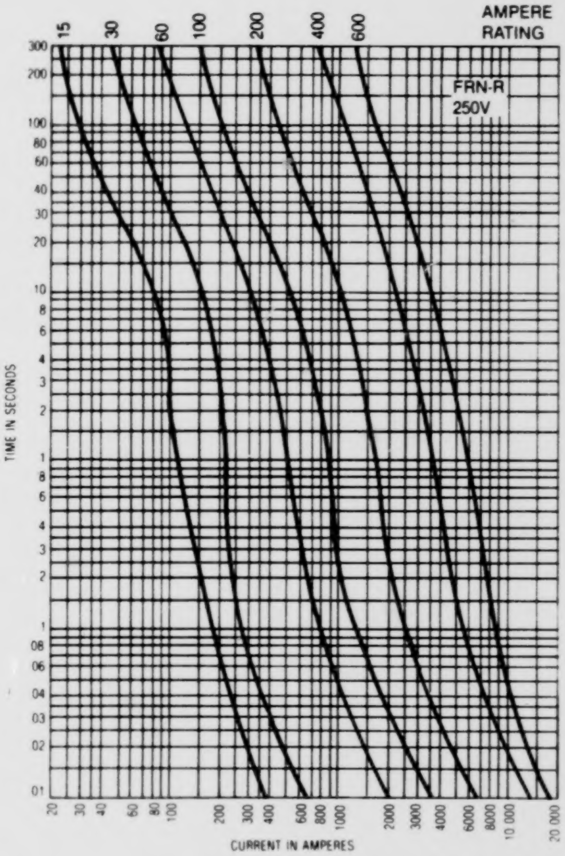
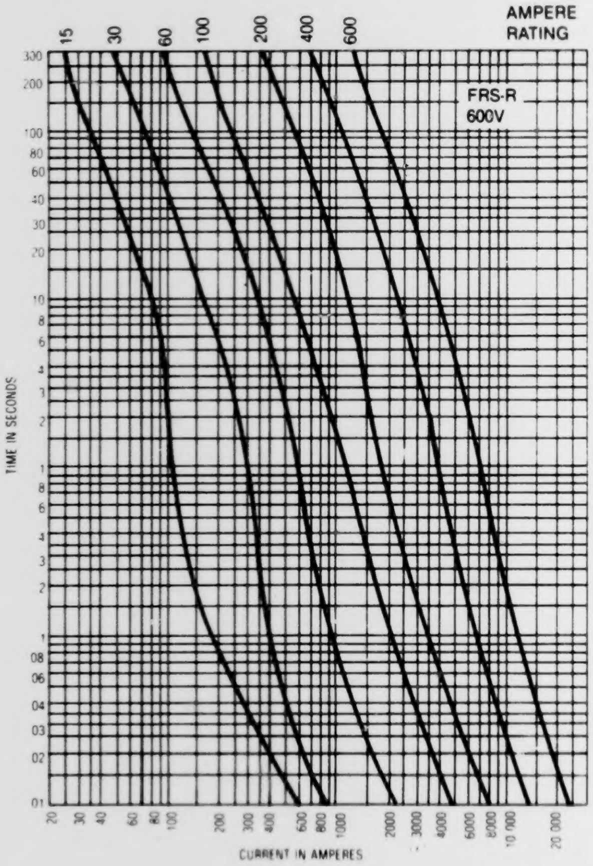
Time-Current Curve Average Melt for Dual-Element Time-Delay FRN-R & FRS-R





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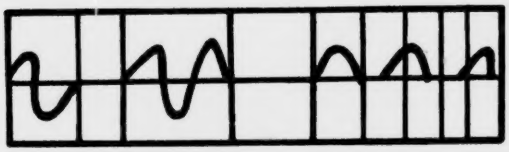
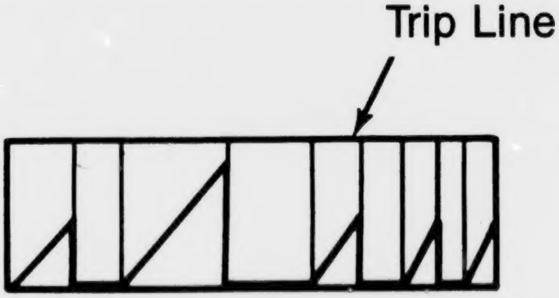
Basic Wiring, Unit 14
Teacher Page 23

TM 4

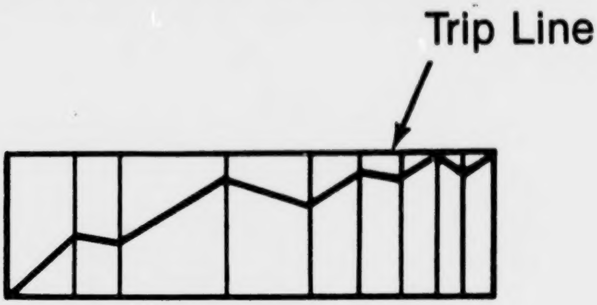
Ground Fault Relaying



Intermittent Ground Fault



Ground Fault Relay Without Memory — Resets After Each Arc



Ground Fault Relay with Memory Circuit — Does Not Reset So Quickly and Trips to Save Expensive Power Equipment

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Overcurrent Protection
Unit 14

Information Sheet

1. **Terms and definitions**

   a. **Air circuit breaker** — Breaker in which all parts operate in air

   b. **Amperage rating** — Maximum current-carrying capacity of a device

   c. **Blade-type cartridge fuse** — Fuse with flat contact blades on a cylindrical case

   d. **Circuit breaker** — Automatic overcurrent device that trips on overloads or shorts and is resettable

   e. **Current-limiting overcurrent protective device** — Device that, when interrupting current in its current-limiting range, reduces the short-circuit current flowing in the faulted circuit to substantially less than would otherwise flow into the fault

   f. **Device** — Electrical equipment that carries or transfers current but does not use it

   g. **Dual-element fuse** — Fuse that has within it a thermal cutout element with a time delay that permits momentary harmless inrush currents to flow without harming the fuse

      Note: Dual-element fuses should not be confused with fuses with two renewable links in a fuse cartridge.

   h. **Edison-base plug fuse** — Fuse with a base that fits the same socket as a regular based incandescent bulb

   i. **Fault current** — Current that flows from one conductor to ground or another conductor because of an abnormal connection or arc between the two

   j. **Ferrule-type cartridge fuse** — Fuse with metal caps on a cylindrical case

   k. **Ground fault** — Accidental connection between an electrical circuit or equipment and the earth or some conducting body that serves in place of the earth

   l. **Ground-fault circuit-interrupter** — Breaker or device designed to protect individuals and equipment by deenergizing or tripping a circuit when current to ground reaches some predetermined value that is less than that required to operate the overcurrent protective device of the supply circuit

Information Sheet

m. **Interrupting rating** — Maximum available short-circuit current that an overcurrent device can safely interrupt without damage to itself

n. **Oil circuit breaker** — Load interrupter in which the interrupting contacts operate submerged in transformer oil

o. **Overcurrent protection** — Weak link in the circuit that limits the amperage to a specified amount

p. **Overload** — Larger than normal current flowing within the normal current path

q. **Selective coordination** — The use of interrupting devices sized and installed so that the one nearest the fault or overloaded machine will open before any of the larger upstream devices open

r. **Short circuit** — Larger than normal current flowing outside the normal current path

s. **Single-element fuse** — Fuse that contains only one element and is not designed to carry an overload

t. **Time current curve** — Plotted curve showing how long a fuse or breaker will carry an overload before opening the circuit

u. **Type "S" plug fuse** — Fuse with special size-limiting characteristics for each amperage range

Note: Refer to *NEC* Article 240-51B.

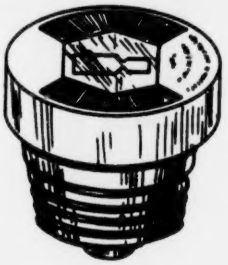
v. **Voltage rating** — Maximum voltage at which a device is designed to operate

Information Sheet

2. **Types of overcurrent protective devices** (Figure 1-5)

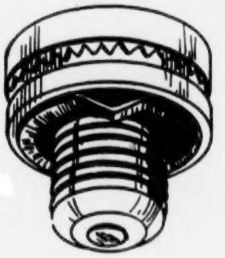
   a. Edison-base plug fuse

   Figure 1



   b. Type "S" plug fuse (fustat)

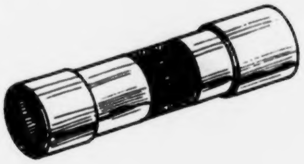
   Figure 2



   c. Ferrule-type cartridge fuse

   Note: Standard ampacities are 15, 20, 30, 40, and 60 amps.

   Figure 3

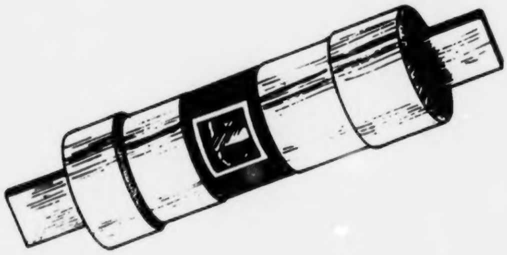


Information Sheet

d. Blade-type cartridge fuse

Note: Standard ampacities start at 65 amps.

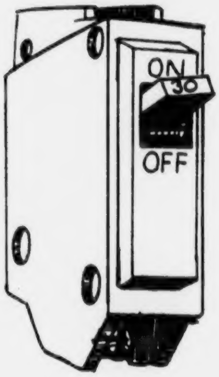
Figure 4



e. Circuit breaker

Note: Standard ampacities start at 15 amps.

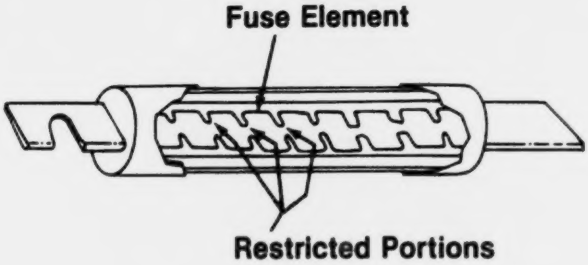
Figure 5



Information Sheet

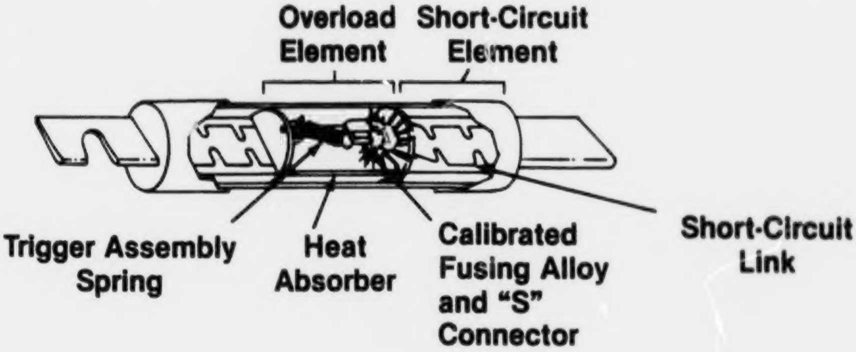
3. **Operation of a single-element fuse** — Under sustained overload conditions, the restricted portions of the fuse element heat to their predetermined melting point, thus opening and interrupting the flow of current.

Figure 6


Fuse Element
Restricted Portions

4. **Operation of a dual-element, time-delay fuse** — Under sustained overload conditions, the trigger spring fractures the fusing alloy and releases the "S" connector.

Figure 7


Overload Element
Short-Circuit Element
Trigger Assembly Spring
Heat Absorber
Calibrated Fusing Alloy and "S" Connector
Short-Circuit Link

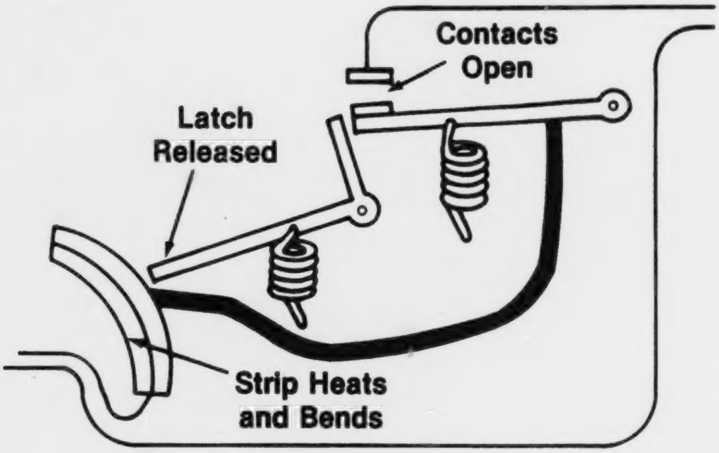
Information Sheet

5. **Types of circuit breakers and their operation** (Figures 8 and 9)

   a. Thermal trip

   - If current flow exceeds the rated limit of the breaker, the bimetallic strip heats and bends.
   - As the strip bends, the latching mechanism is tripped and the contacts open.

Figure 8


Contacts Open
Latch Released
Strip Heats and Bends

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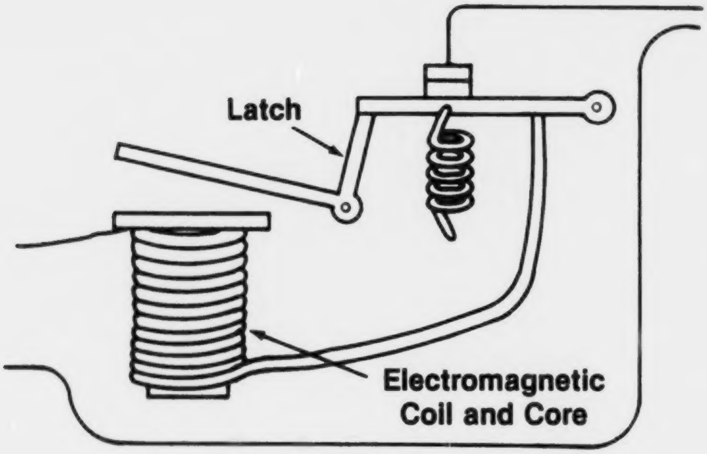
Information Sheet

b. Electromagnetic trip

- As current flows through the breaker, it creates a magnetic field within the coil. During sustained overload conditions, the magnetic field interferes and draws the core into the coil.
- The metal trip bar is attracted to the core forcing the latch to move, thus opening the contacts.

Figure 9



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6. Requirements for fuses of less than 600 volts

Note: Refer to *NEC* Article 240.

a. Plug fuses shall not be used in circuits exceeding 125 volts between conductors.

b. Fuses shall be marked with their amperage rating.

c. Plug fuses shall be classified 0 to 30 amperes.

d. Edison-base plug fuses shall only be used for replacement in existing installations where there is no evidence of overfusing or tampering.

e. Type "S" fuses (fustats) shall be classified at not over 125 volts.

Note: Refer to *NEC* Article 240-51B.

Information Sheet

f. Type "S" fuses shall be classified as 0 to 15, 16 to 20, and 21 to 30 amperes.

g. Different ampere classes of type "S" fuses are not interchangeable.

h. Cartridge fuses shall be marked with their ampere rating, voltage rating, and the name or trademark of the manufacturer.

7. Requirements for circuit breakers of less than 600 volts

Note: Refer to *NEC* Article 240.

a. Circuit breakers shall be capable of being manually tripped and set.

   Note: Where used as switches in 120- and 277-volt fluorescent lighting circuits, breakers shall be approved for such switching duty and shall be marked "SWD."

b. Circuit breakers shall have a visible "off" and "on" indication.

c. The breaker shall be designed so that any change of its trip point (ampere rating) or time required for operation will require dismantling or the breaking of a seal.

d. Circuit breakers shall be marked with their ampere rating in a manner that will be durable and visible by removal of a trim or cover.

e. Every circuit breaker having an interrupting rating other than 5,000 amperes shall have its interrupting rating shown on the circuit breaker.

8. Installations that require GFCI protection

a. All 125-volt, single-phase, 15- and 20-ampere receptacles that are not part of the permanent wiring on construction sites

b. All 125-volt, single-phase, 15- and 20-ampere receptacles installed in bathrooms

c. All 125-volt, single-phase, 15- and 20-ampere receptacles installed in garages

d. All 125-volt, 15- and 20-ampere receptacles installed outdoors where there is direct grade level

e. All 125-volt, 15- and 20-ampere receptacles in crawl spaces at or below grade level and in unfinished basements

f. All 125-volt, 15- and 20-ampere receptacles within 6 feet of a wet bar sink or kitchen sink that serves counter top surfaces

g. All 125-volt, 15- and 20-ampere receptacles installed in boathouses

Information Sheet

h. All 125-volt, 15- and 20-ampere receptacles installed in bathrooms of commercial, industrial, and all nondwelling occupancies

i. All 125-volt, 15- and 20-ampere receptacles installed on roofs

j. Lighting fixtures and lighting outlets installed in the area extending between 5 feet and 10 feet horizontally from the inside walls of a pool, unless installed 5 feet above maximum water level and rigidly attached to structure adjacent to or enclosing the pool

Overcurrent Protection
Unit 14

Assignment Sheet 1—Calculate Fuse Sizes

Name ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
Assignment answers complete	______
Minimum of fifteen of sixteen answers correct per Answers to Assignment Sheet 1	______

The electrical technician should be able to calculate appropriate fuse sizes by referring to reference materials and charts and by calculating percentages correctly.

Directions: Using the information furnished on the following page and the *National Electrical Code*, size the fuses shown on the line diagram. The information is for dual-element time-delay fuses. Refer to Article 220-10 for sizing feeders. Refer to Article 430 for information on sizing motor fuses.

1. **Main Service** — Size the fuse according to the method described in 4.
2. **Feeder with no motor load** — The fuse size must be at least 125% of the continuous load, plus 100% of the noncontinuous load.
3. **Feeder with all motor loads** — The fuse must be sized at 150% of the full load current of the largest motor, plus the full load current of all other motors.
4. **Feeder circuit with mixed loads** — Size the fuse at the sum of:
    a. 150% of the full load current of the largest motor
    b. 100% of the full load current of all other motors
    c. 125% of the continuous, nonmotor load
    d. 100% of the noncontinuous, nonmotor load
5. **Branch circuit with no motor load** — The fuse must be sized at least 125% of the continuous load, plus 100% of the noncontinuous load. (Do not size larger than the ampacity of the conductor.)

Assignment Sheet 1

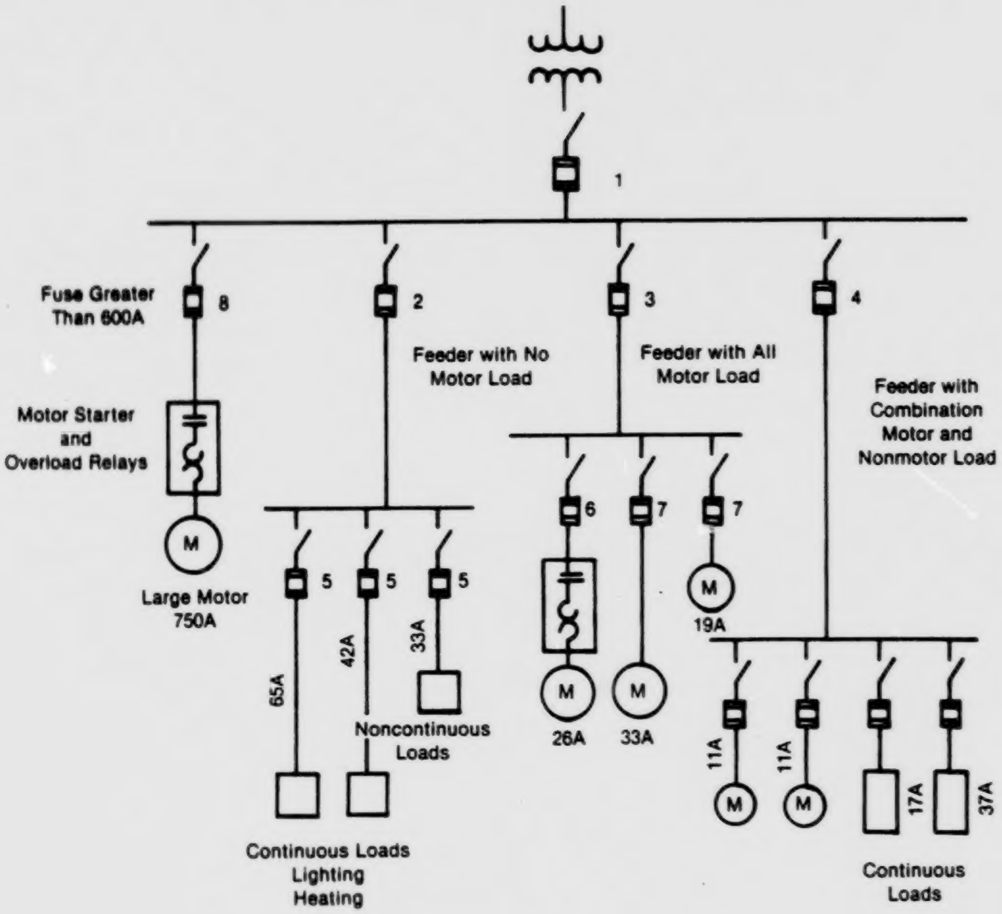
6. **Motor branch circuit with overload relays** — When overload relays are sized to provide running overload protection, a and b below will provide ground fault and short circuit protection.

   a. **Motors with 1.15 service factor or 40°C rise** — Size fuse at 125% of motor full load current or next higher standard size.
   b. **Motors less than 1.15 service factor or over 40°C rise** — Size fuse at 115% of motor full load current or next higher standard size fuse.

7. **Motor branch circuit with fuse protection only** — Where the fuse is the only motor protection, the following fuses will provide motor running overload and short-circuit protection.

   a. **Motors with a 1.15 service factor or 40°C rise** — Size fuse at 110% to 125% of motor full load current.
   b. **Motors with less than 1.15 service factor or over 40°C rise** — Size fuse at 100% to 115% of motor full load current.

Assignment Sheet 1


1
Fuse Greater Than 600A
8
2
3
4
Feeder with No Motor Load
Feeder with All Motor Load
Feeder with Combination Motor and Nonmotor Load
Motor Starter and Overload Relays
M
Large Motor 750A
5
5
5
6
7
7
M
19A
65A
42A
33A
Noncontinuous Loads
M
M
26A
33A
11A
11A
M
M
17A
37A
Continuous Loads Lighting Heating
Continuous Loads

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M1 - 3 HP 3ϕ 1.15 SF (overload relays used)
M2 - 5 HP 3ϕ 1.00 SF (overload relays used)
M3 - 3 HP 3ϕ 1.00 SF (overload relays used)
M4 - 10 HP 3ϕ 40°C Rise (overload relays used)
M5 - 7.5 HP 3ϕ 60°C Rise (overload relays used)
M6 - 20 HP 3ϕ 40°C Rise (overload relays used)
M7 - 2 HP 1ϕ 1.10 SF (no overload relays)

Assignment Sheet 1

A. What size fuse is required for motor M1, and what size THWN conductor is needed?

Fuse = ________________ Conductor = ________________

B. What size fuse is required for motor M2, and what size THHN conductor is needed?

Fuse = ________________ Conductor = ________________

C. Motor M3 will require what size THW conductor and what size fuse?

Fuse = ________________ Conductor = ________________

D. Motor M4 will use a THHN conductor of what size and require what size fuse?

Fuse = ________________ Conductor = ________________

E. What size THWN conductor, and what size fuse will M5 require?

Fuse = ________________ Conductor = ________________

F. What fuse size will motor M6 require, and what size THWN conductor will be needed?

Fuse = ________________ Conductor = ________________

G. What size THW feeder will be needed for the motor control center, and what size fuse will be required?

Fuse = ________________ Conductor = ________________

H. What size fuse and THHN conductor are needed for the 20-amp continuous-load branch circuit?

Fuse = ________________ Conductor = ________________

I. What size THHN conductor and what ampacity fuse are required for the 40-amp noncontinuous-load, branch circuit?

Fuse = ________________ Conductor = ________________

J. What size fuse and what size type Z conductor will be required for the 60-amp continuous heating load?

Fuse = ________________ Conductor = ________________

K. What size THHN conductor and what size fuse will be needed for the feeder circuit with no motor loads?

Fuse = ________________ Conductor = ________________

Assignment Sheet 1

L. What size THHN conductor and what size fuse will the 40-amp continuous-load require?

Fuse = ____________________ Conductor = ____________________

M. Motor M7 does not have overload relays. What size fuse and what size THHN conductor will be required?

Fuse = ____________________ Conductor ____________________

N. What size THHN conductor and what size fuse will be required for the feeder with mixed loads?

Fuse = ____________________ Conductor = ____________________

O. The 50-amp noncontinuous branch circuit load will require what size fuse and what size THW conductor?

Fuse = ____________________ Conductor = ____________________

P. What size THWN conductor and what size main fuse will the main feeder require?

Fuse = ____________________ Conductor = ____________________

Overcurrent Protection
Unit 14

Job Sheet 1—Test Cartridge Fuses

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Gathered and used appropriate equipment and materials	______
Performed procedure safely	______
Performed all steps in procedure	______
Cleaned work area	______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the above criteria.

A. Equipment and material

Eye protection
Live disconnect
Several fuses, both good and bad
Voltmeter for voltage to be tested
Gloves

B. Procedure

Caution: Live voltages are present during this test. Observe proper safety precautions.

☐ 1. Put on eye protection.

☐ 2. Deenergize disconnect.

☐ 3. Install fuses.

☐ 4. Energize disconnect and leave disconnect door open.

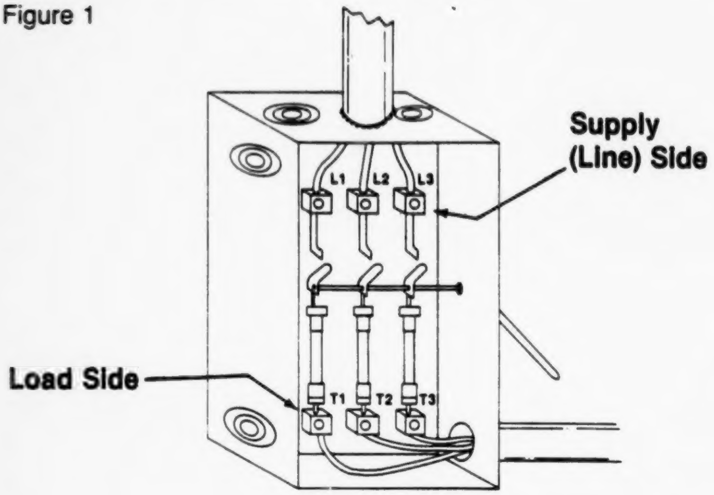
☐ 5. Set voltmeter to appropriate voltage scale.

Job Sheet 1

☐ 6. Test voltage on supply side of disconnect. (Figure 1)

(Note: On a 208-volt, three-phase disconnect, 208 volts should be present from L1 to L2, L1 to L3, and L2 to L3.

Figure 1



☐ 7. Place voltmeter probe #1 on L1 terminal and probe #2 on T2 terminal; voltage should be 208 volts.

☐ 8. Move probe #2 to T3 terminal; voltage should be 208 volts.

☐ 9. Move problem #1 to L2 terminal and probe #2 to T1 terminal; voltage should be 208 volts.

☐ 10. Move probe #2 to T3 terminal; voltage should be 208 volts.

☐ 11. Move probe #1 to L3 terminal and problem #2 to T1 terminal; voltage should be 208 volts.

☐ 12. Move probe #2 to T2 terminal; voltage should be 208 volts.

Note: A lower voltage or no voltage indicates a bad fuse. When meter shows low or no voltage, probe #2 will always be under the fuse that is bad.

☐ 13. Repeat Steps 2 through 12 using different fuses.

Note: Have instructor evaluate work.

☐ 14. Clean work area, and return equipment and materials to proper storage.

Evaluator's comments: ____

____

____

Load Centers and Safety Switches
Unit 15

Objective Sheet

Unit Objective

After completing this unit, the student should be able to identify parts and components of load centers and safety switches as well as install them. The student should demonstrate these competencies by completing the assignment and job sheets and scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to load centers and safety switches with their correct definitions.
2. Identify types of safety switch enclosures.
3. Identify safety switch system configurations.
4. Identify types of load centers and enclosures.
5. Match common load center accessories with their uses.
6. Label the parts of a fusible, single-phase load center.
7. Label the parts of a breaker load center.
8. Identify common panel bus configurations.
9. Select true statements about safety rules for working near load centers and safety switches.
10. Using the *NEC*, answer questions related to load centers. (Assignment Sheet 1)
11. Install a safety switch. (Job Sheet 1)
12. Wire a load center or breaker panel. (Job Sheet 2)
13. Wire a receptacle circuit to a load center. (Job Sheet 3)

Load Centers and Safety Switches
Unit 15

Suggested Activities

Instructional Plan

Preparation

1. Read the unit carefully and plan for instruction. Study the specific objectives to determine the order in which you will present them.

2. Review Teaching Suggestions section that follows. Plan for classroom activities.

3. Plan your presentation to take advantage of student learning styles and to accommodate special needs students.

4. Make transparencies from the transparency masters included with this unit. These appear in the teacher edition only and are designed to be used with the following objectives:

   TM 1—Parts of a Fusible, Single-Phase Center Suitable for Service Equipment (Objective 6)
   TM 2—Parts of a Breaker Load Center (Objective 7)

5. Obtain films, videotapes, and other resources to supplement instruction of this unit. See ordering information in the Suggested Supplemental Resources section that follows.

6. Develop teaching plan. Adjust for different learning styles.

7. Make copies of Unit Evaluation Form.

Delivery and Application

8. Provide students with unit of instruction.

9. Discuss unit and specific objectives.

10. Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.

11. Discuss the assignment sheet and schedule due date. Review criteria for evaluation of these activities.

12. Discuss and demonstrate the job sheets. Review criteria for evaluation of these activities.

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Suggested Activities

Evaluation

13. Discuss the use of the Unit Evaluation Form with students. Discuss the rating scale that will be used for student evaluation.

14. Make copies of the written test. Add or modify test items as needed.

15. Give written test.

16. Compile assignment and job sheet ratings and written test scores on the Unit Evaluation Form. Add any additional assignments or supplemental activities that should be part of the unit evaluation.

17. Reteach and retest as required.

Teaching Suggestions

Note: Skill areas appearing in boldface type in the Teaching Suggestions refer to the academic and workplace skills identified by the American Society for Training and Development (ASTD) and the U.S. Department of Labor. These have been adapted by MAVCC.

1. Tour the school and residential construction sites to view various load center and safety switch installations. Skill area: **Applied science**

2. Show the class examples of load centers and safety switches, pointing out the purposes of their structural differences. Skill area: **Listening**

3. Stress the importance of branch circuit overcurrent protection and relate to unit on conductors. Skill area: **Listening**

Resources Used in Developing This Unit

1. *Digest.* Park Ridge, IL: Square D Company, 1987.

2. Earley, Mark W., John M. Caloggero, and Richard H. Murray. *National Electrical Code 1993.* Quincy, MA: National Fire Protection Association, 1992.

3. *Industrial Control Catalog, 1986-87.* Milwaukee, WI: Cutter-Hammer Products, 1986.

4. Taylor Mark. *Residential Wiring.* Stillwater, OK: Mid-America Vocational Curriculum Consortium 1983.

Suggested Activities

Suggested Supplemental Resource

Catalog — *Selection Guide*. Cutter-Hammer/Power Distribution Products, 4201 North 27th Street, Milwaukee, Wisconsin.

Instructions for Evaluating Student Performance

Assignment Sheets—Be sure the student understands the criteria on which the evaluation is based. Assign a point value to each criterion and convert the total points to a percentage for grading.

Job Sheets—Be sure the student understands the criteria on which the evaluation is based. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in either the teacher edition or student manual. Then observe the student performing the procedure. Rate both process and product.

> Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily achieved the step(s) for each checkpoint area. If the student is unable to correctly complete the procedure, have the student review the materials and try again.
>
> Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria which have been provided as part of the job sheet. Complete the rating by assigning a point value to each criterion and by converting the point total to a percentage for grading. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) which best fits your program needs.

Option A

4 - Skilled—Can perform job with no additional training.
3 - Moderately skilled—Has performed job during training program; limited additional training may be required.
2 - Limited skill—Has performed job during training program; additional training is required to develop skill.
1 - Unskilled—Is familiar with process, but is unable to perform job.

Option B

Yes—Can perform job with no additional training.

No—Is unable to perform job satisfactorily.

Load Centers and Safety Switches
Unit 15

Answers to Assignment Sheet 1

A. No, Ref. 384-4, No. 1; not a room, but a space as described in 110-16
B. 240, 250, 370, 373, 380, 500 through 517; Ref. 384-2
C. 6 inches; Ref. 384-3(g), 373-6(b), Table 373-6(b)
D. 42; Ref. 384-15
E. No; Ref. 384-17, 373-2(a)
F. No; Ref. 384-20
G. Yes; Ref. 384-18
H. 3 feet; Ref. 384-8, 110-16

Load Centers and Safety Switches
Unit 15

Answers to Written Test

1.	a.	8	e.	12	i.	4	m.	16
	b.	9	f.	13	j.	5	n.	3
	c.	10	g.	14	k.	6	o.	2
	d.	11	h.	1	l.	15	p.	7

2. a. NEMA 1 (indoor)
   b. NEMA 3R (rainproof)
   c. NEMA 4X (watertight, corrosion resistant)

3. a. 2-pole nonfusible, 2 blades
   b. 4-wire S/N 3 blades, 3 fuses
   c. 2-wire S/N 1 blade, 1 fuse
   d. 2-wire 2 blades, 2 fuses
   e. 3-pole nonfusible
   f. 3-pole fusible (S/N)
   g. 3-wire S/N 2 blades, 2 fuses
   h. Three-pole, double-throw

4. a. Flush mount (NEMA 1)
   b. Surface mount (generally NEMA 1)
   c. Exterior surface (NEMA 3R)

5.	a.	1	d.	6	g.	5
	b.	4	e.	7	h.	8
	c.	4	f.	2	i.	3

6. a. Grounded (neutral) bar
   b. Grounding bar
   c. Main fuse pullout
   d. Line lugs
   e. Plug fuse sockets
   f. Pull outs

7. a. Main breaker line lugs
   b. Grounded (neutral) bar
   c. Main breaker
   d. Bus bars
   e. Pole spaces

8. a. Main breaker single phase
   b. Main lug only (MLO) single phase
   c. Split bus single phase
   d. Double split bus single phase
   e. Three-phase MLO

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9. a, b, c, d

Load Centers and Safety Switches
Unit 15

Written Test

Name ______________________________ Score ______________

1. Match terms related to load centers and safety switches with their correct definitions. Write the correct numbers in the blanks. Definitions are continued on the next page.

_____a. Organization responsible for setting specifications for various classes of enclosures

_____b. General purpose enclosure for use indoors under usual service conditions

_____c. Driptight enclosure used indoors to exclude falling moisture and dirt

_____d. Weather resistant (weatherproof) enclosure suitable for indoor or outdoor use; will exclude falling dirt, light liquid splashing, rain, show, sleet, and windblown dust

_____e. Watertight and dustproof enclosure suitable for areas where a great amount of splashing occurs, such as hose down areas

_____f. Dust-tight enclosure not suitable for use around water

_____g. Industrial use enclosure designed to exclude oil, coolant, flying dust and lint, and falling dirt

_____h. Enclosure designed either for surface or flush mounting and provided with a frame, mat, or trim in which a swinging door or doors are or may be hung

1. Cabinet
2. Concentric knockout
3. Dead front
4. Disconnecting means
5. Dustproof
6. Dust-tight
7. Eccentric knockout
8. NEMA (National Electrical Manufacturer's Association)
9. NEMA Type 1
10. NEMA Type 2
11. NEMA Type 3
12. NEMA Type 4
13. NEMA Type 5
14. NEMA Type 12
15. Rainproof
16. Raintight

Written Test

_______i. A device or group of devices, or other means, by which the conductors of a circuit can be disconnected from their source of supply

_______j. So constructed or protected that dust will not interfere with its successful operation

_______k. So constructed that dust will not enter the enclosing case

_______l. So constructed, protected, or treated as to prevent rain from interfering with successful operation of the apparatus

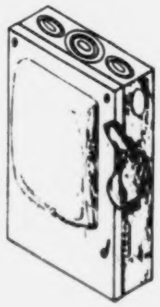
_______m. So constructed or protected that exposure to a beating rain will not result in the entrance of water

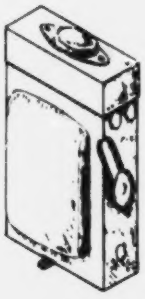
_______n. Removable cover used to prevent exposure of live parts to persons on the operating side of the equipment

_______o. Several removable metal rings that allow for the entrance of various standard sizes of connectors into a cabinet

_______p. Knockout that is removed in sections to form larger holes

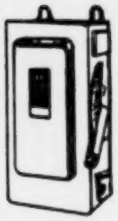
2. Identify the following types of safety switch enclosures. Write the correct names in the blanks.





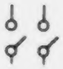
a. ______________________________ b. ______________________________

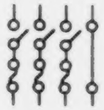
Written Test

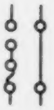


c. ____________________

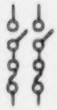
3. Identify the safety switch system configurations below. Write the correct names in the blanks.

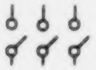


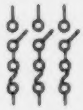




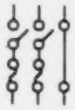
a. ____________ b. ____________ c. ____________

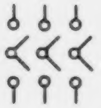






d. ____________ e. ____________ f. ____________

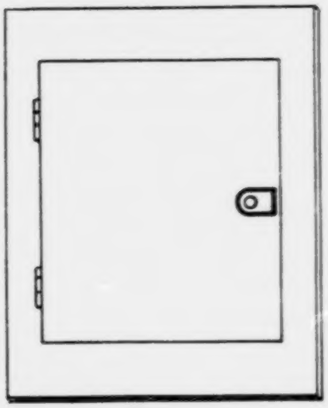


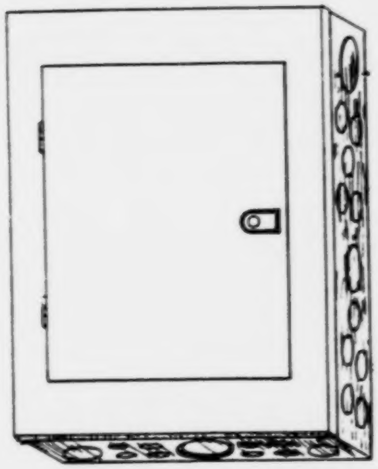


g. ____________________ h. ____________________

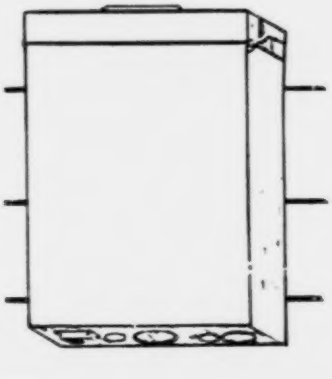
Written Test

4. Identify the types of load centers and enclosures below. Write the correct names in the blanks.





a. ______________________ b. ______________________



c. ______________________

910

Written Test

5. Match common load center accessories with their uses. Write the correct numbers in the blanks.

_______a. Used for termination of conductors

_______b. Used for termination of circuit grounded conductors

_______c. Used for termination of equipment grounding conductors

_______d. Used for locking of cabinet doors to allow entrance of qualified personnel only

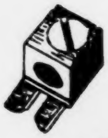
_______e. Used to lock breakers in the "off" or "on" position

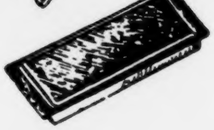
_______f. Used to fill empty breaker spaces where "breakouts" have been removed

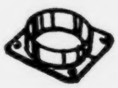
_______g. Used to lock breakers in the "off" position for equipment maintenance or servicing

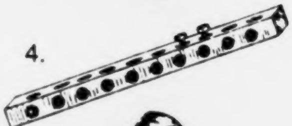
_______h. Used to mechanically tie two or more breaker handles together to assure common tripping

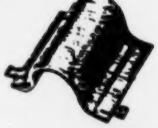
_______i. Used to allow entrance of conduits to rainproof enclosures

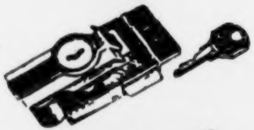
1. 

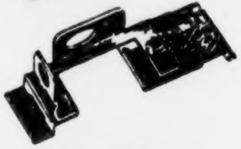
2. 

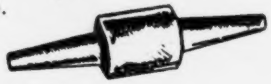
3. 

4. 

5. 

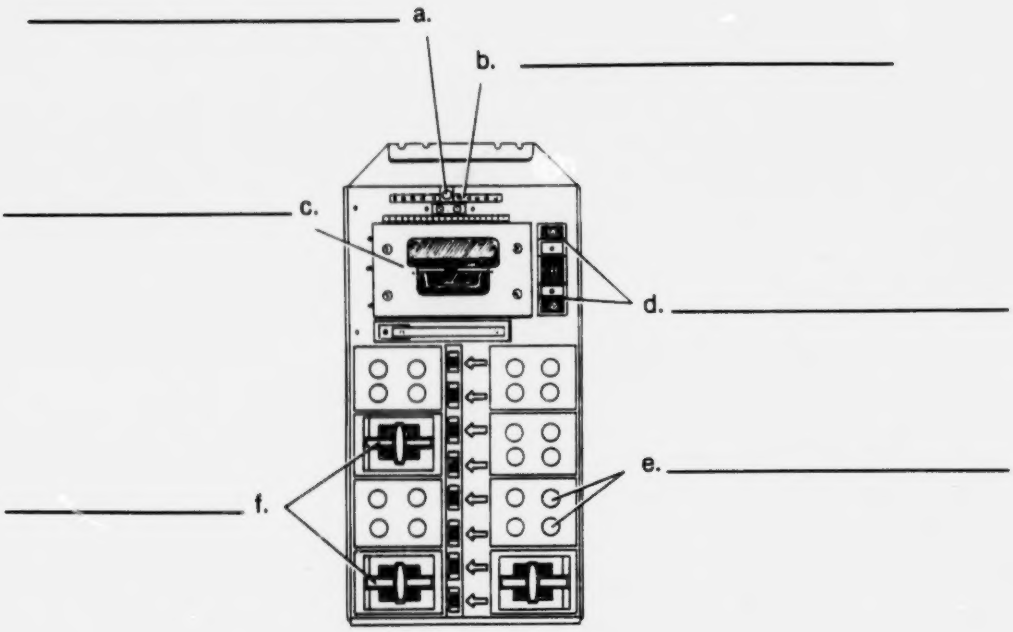
6. 

7. 

8. 

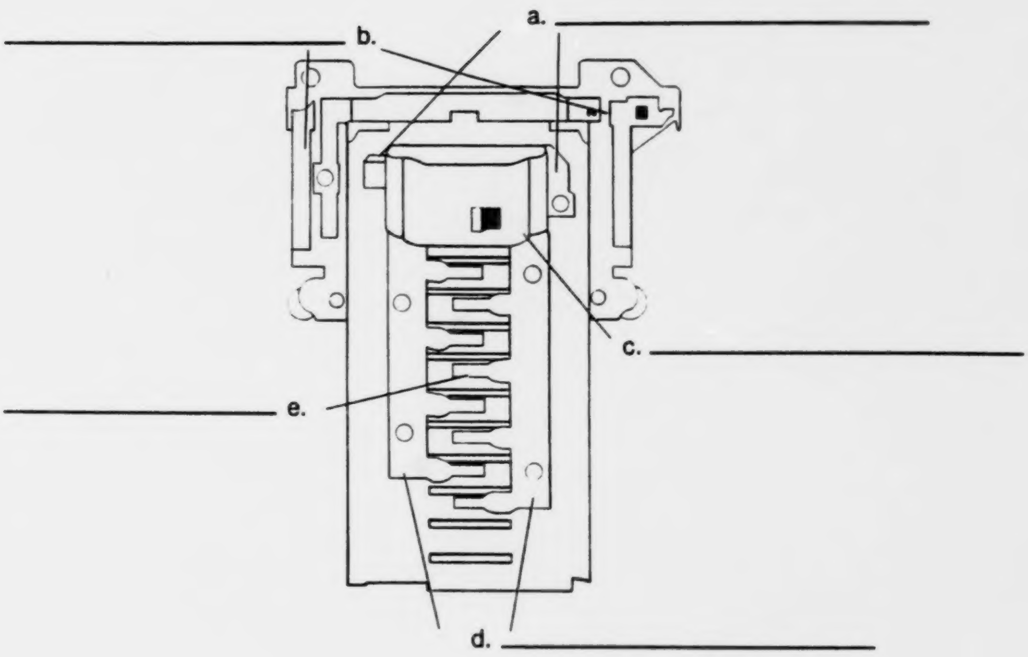
Written Test

6. Label the parts of the fusible, single-phase load center illustrated below.



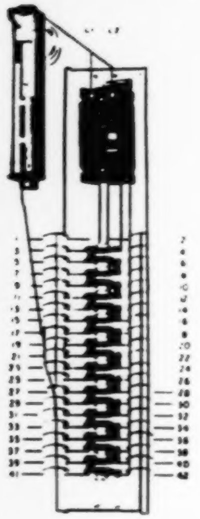
Written Test

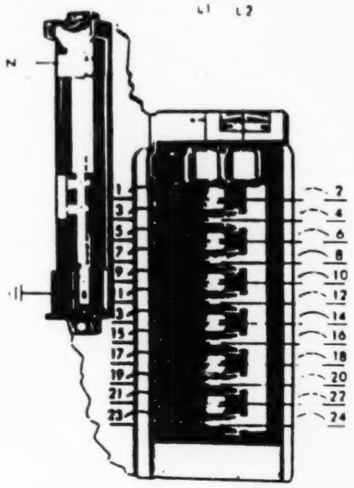
7. Label the parts of the breaker load center illustrated below.

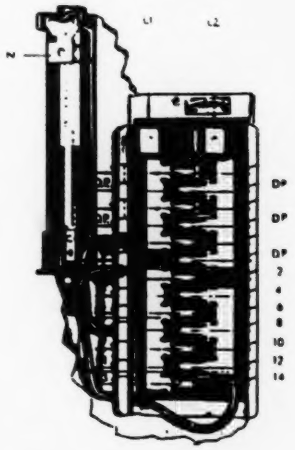


Written Test

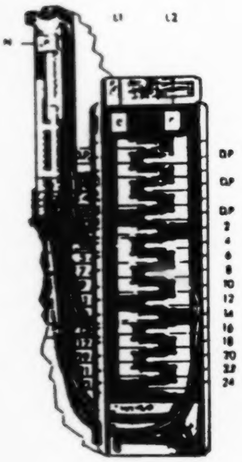
8. Identify the common panel interior configurations shown below. Write the correct names in the blanks.

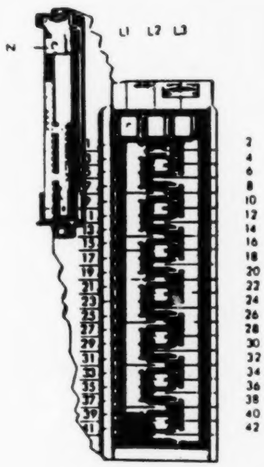



L1 L2
Z
1
3
5
7
9
11
13
15
17
19
21
23
2
4
6
8
10
12
14
16
18
20
22
24


L1 L2
Z
DP
DP
DP
2
4
6
8
10
12
14

a. ______________ b. ______________ c. ______________


L1 L2
Z
DP
DP
DP
2
4
6
8
10
12
14
16
18
20
22
24


L1 L2 L3
Z
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42

d. ________________________ e. ________________________

Written Test

9. Select true statements about safety rules for working near load centers and safety switches. Write an "X" in the blank before each true statement.

______a. Do not tamper with or alter equipment.

______b. Install for intended purpose.

______c. Install according to *NEC*.

______d. Do not hold extra tools in your hand during installation or maintenance.

______e. Stand in front of a disconnect before energizing it.

***Permission to duplicate this test is granted.**

Load Centers and Safety Switches
Unit 15

Unit Evaluation Form

Student Name ______________________________ Unit Rating __________

Assignment Sheet 1—Use the *NEC* to Answer Questions Related to Load Centers Rating ______

Comments: ____

____

Job Sheet 1—Install a Safety Switch Rating ______

Comments: ____

____

Job Sheet 2—Wire a Load Center or Breaker Panel Rating ______

Comments: ____

____

Job Sheet 3—Wire a Receptacle Circuit to a Load Center Rating ______

Comments: ____

____

Written Test Scores

Pretest ______ Posttest ______ Other ______

Other ____

____

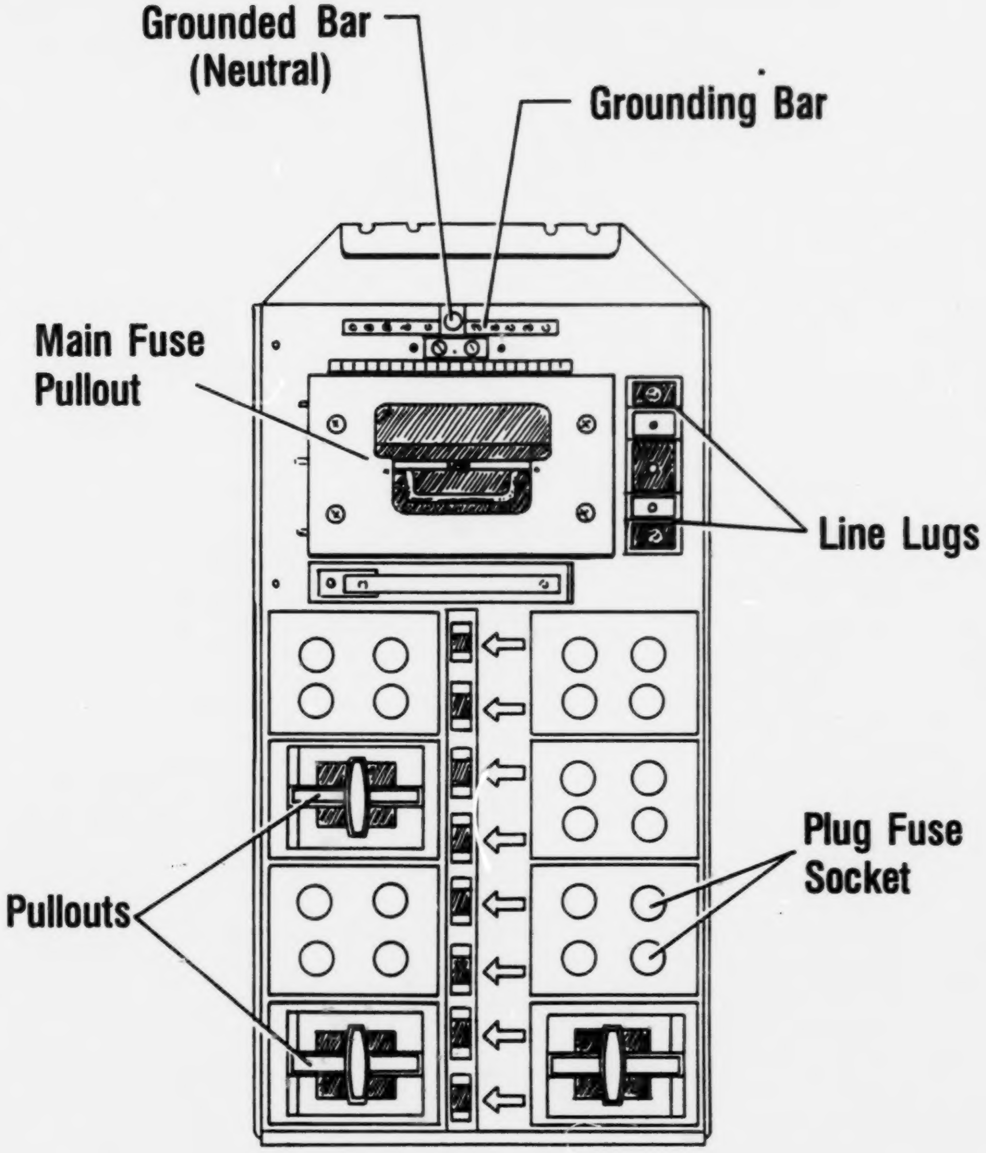
Teacher Signature ______________________________ Date __________

Student Signature ______________________________ Date __________

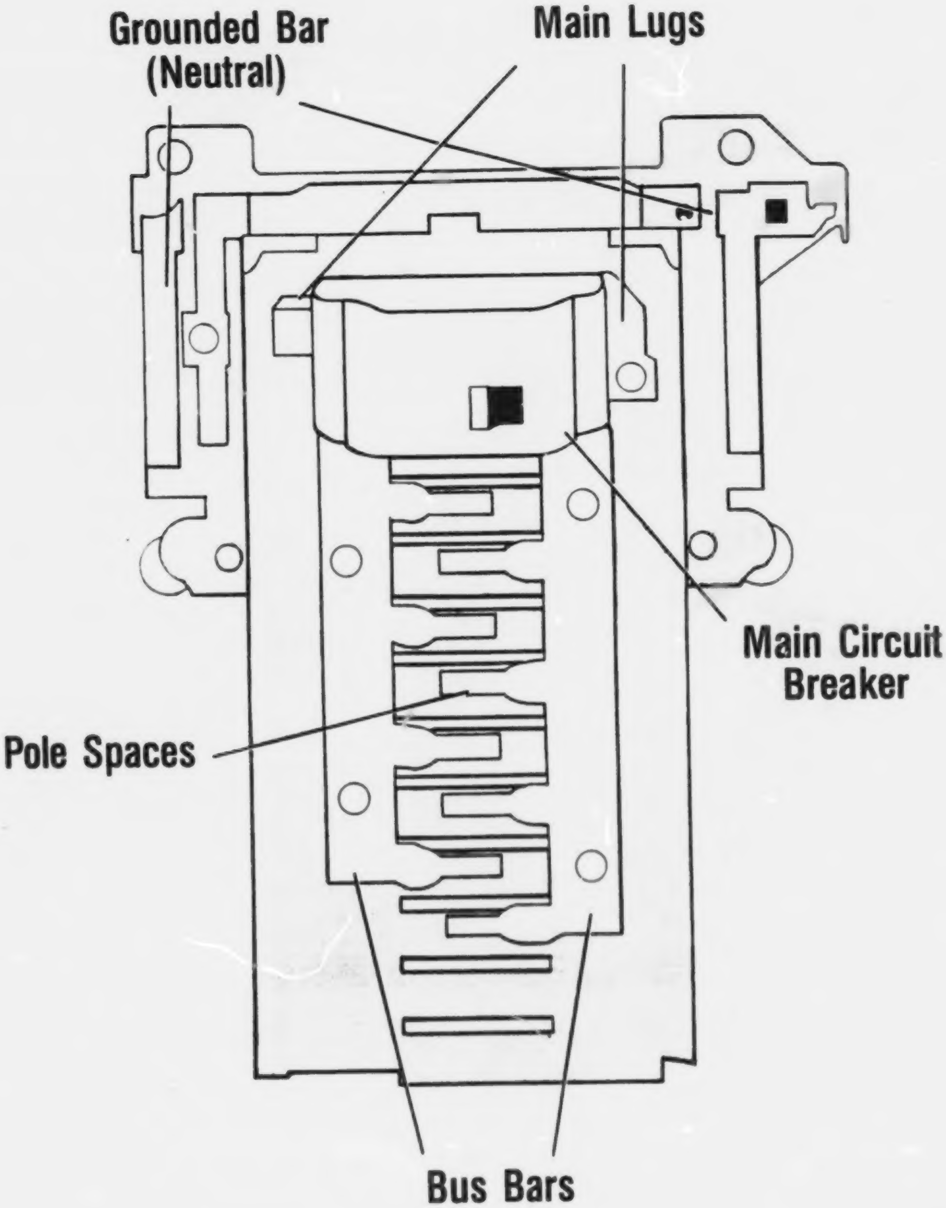
***Permission to duplicate this form is granted.**

916

Parts of a Fusible Single-Phase Load Center Suitable for Service Equipment


Grounded Bar
(Neutral)
Grounding Bar
Main Fuse
Pullout
Line Lugs
Plug Fuse
Socket
Pullouts

Parts of a Breaker Load Center


Grounded Bar (Neutral)
Main Lugs
Main Circuit Breaker
Pole Spaces
Bus Bars

Load Centers and Safety Switches
Unit 15

Information Sheet

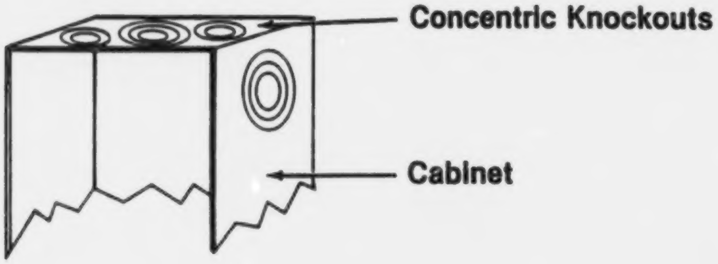
1. **Terms and definitions** (Figures 1-3)

   a. **Cabinet** — An enclosure designed either for surface or flush mounting and provided with a frame, mat, or trim in which a swinging door or doors are or may be hung

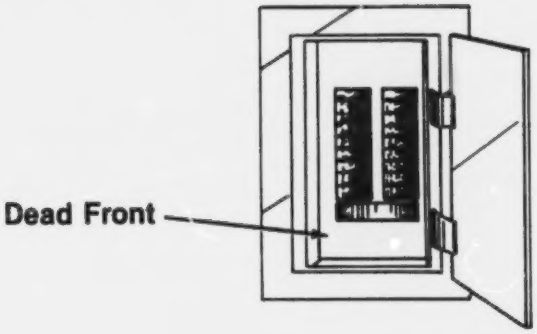
   b. **Concentric knockout** — Several removable metal rings that allow for the entrance of various standard sizes of connectors into a cabinet (Figure 1)

   Note: Standard concentric knockout sizes are ½ inch, ¾ inch, 1 inch, 1¼ inches, 1½ inches, 2 inches, and 2½ inches.

   Figure 1



   c. **Dead front** — Removable cover used to prevent exposure of live parts to persons on the operating side of the equipment (Figure 2)



   d. **Disconnecting means** — A device or group of devices, or other means, by which the conductors of a circuit can be disconnected from their source of supply

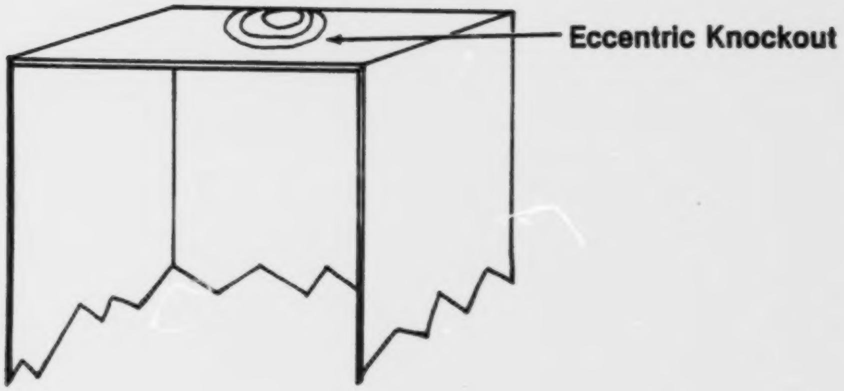
Information Sheet

e. **Dustproof** - So constructed or protected that dust will not interfere with its successful operation

f. **Dust-tight** — So constructed that dust will not enter the enclosing case

g. **Eccentric knockout** — Knockout that is removed in sections to form larger holes (Figure 3)

Figure 3



h. **NEMA (National Electrical Manufacturer's Association)** — Organization responsible for setting specifications for various classes of enclosures

i. **NEMA Type 1** — General purpose enclosure for use indoors under usual service conditions

j. **NEMA Type 2** — Driptight enclosure used indoors to exclude falling moisture and dirt

k. **NEMA Type 3** — Weather resistant (weatherproof) enclosures suitable for indoor or outdoor use; will exclude falling dirt, light liquid splashing, rain, show, sleet, and windblown dust

Note: Descriptors placed after the code number specify the suitable applications. A NEMA Type 3R is a common residential outdoor enclosure. The R stands for raintight and signifies that the enclosure will not exclude windblown dust.

Information Sheet

l. **NEMA Type 4** — Watertight and dustproof enclosure suitable for areas where a great amount of splashing occurs, such as hose down areas

m. **NEMA Type 5** — Dust-tight enclosure not suitable for use around water

Note: All NEMA Type 12 enclosures and JIC (Joint Industry Conference) enclosures are suitable for NEMA Type 5 applications.

n. **NEMA Type 12** — Industrial use enclosure designed to exclude oil, coolant, flying dust and lint, and falling dirt

o. **Rainproof** — So constructed, protected, or treated as to prevent rain from interfering with successful operation of the apparatus

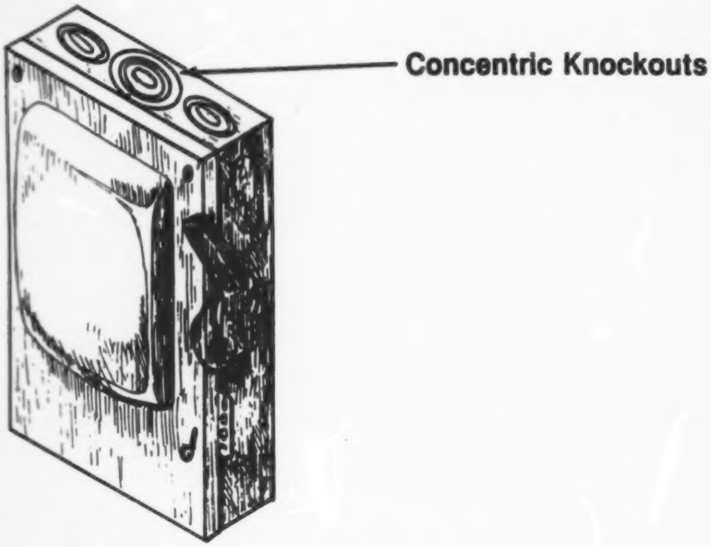
p. **Raintight** — So constructed or protected that exposure to a beating rain will not result in the entrance of water

2. **Types of safety switch enclosures** (Figures 4-6)

a. NEMA 1 (indoor)

Note: NEMA 1 safety switch enclosures may be easily identified because of the presence of concentric knockouts on the top of the enclosure.

Figure 4

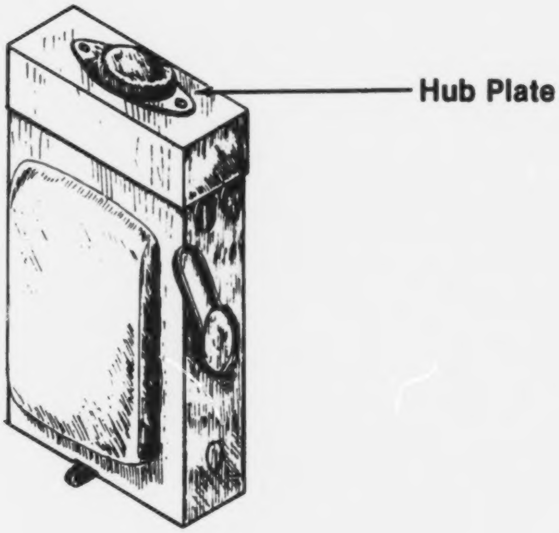


Information Sheet

b. NEMA 3R (rainproof)

Note: NEMA 3R safety switch enclosures may be easily identified by the presence of a hub plate on the top of the safety switch.

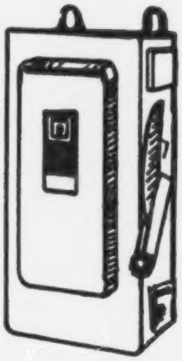
Figure 5



c. NEMA 4X (watertight, corrosion resistant)

Note: NEMA 4X enclosures are generally constructed of stainless steel.

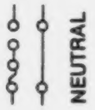
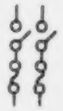
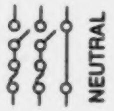
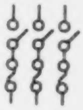
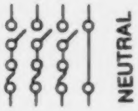
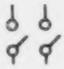
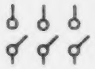
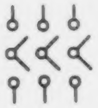
Figure 6



Information Sheet

3. Safety switch system configurations (Figure 7)

Figure 7

 2-wire S/N 1 blade, 1 fuse	 2-wire 2 blades, 2 fuses	 3-wire S/N 2 blades, 2 fuses
 3-pole fusible S/N	 4-wire S/N 3 blades, 3 fuses	 2-pole nonfusible 2 blades
 3-pole nonfusible	 3-pole, double-throw	

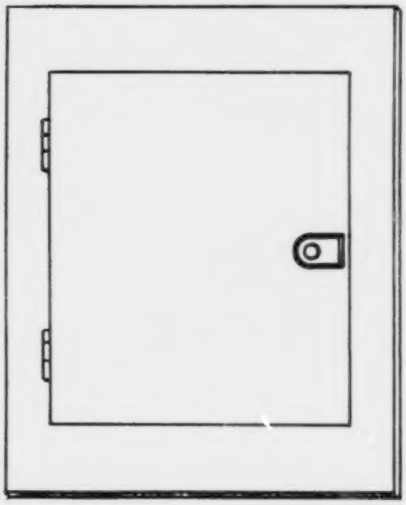
*S/N designates "solid neutral."

Information Sheet

4. **Types of load centers and enclosures** (Figures 8-10)

   a. Flush mount (NEMA 1)

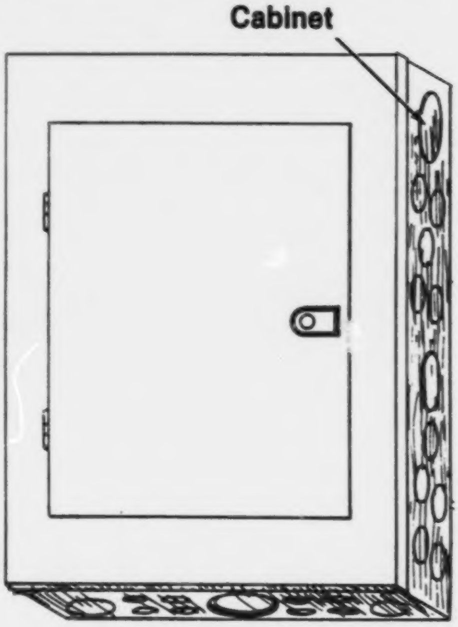
Figure 8



   b. Surface mount (generally NEMA 1)

Note: In most cases surface-mount and flush-mount load centers use the same cabinets; however, other cabinets may be ordered for special installations.

Figure 9

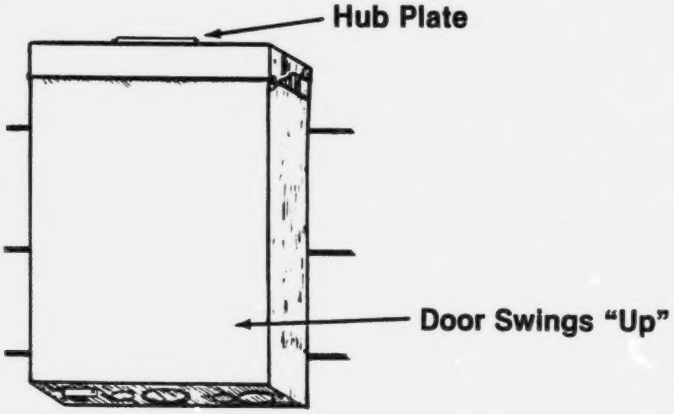


Information Sheet

c. Exterior surface (NEMA 3R)

Note: NEMA 3R load center enclosures are identified by the presence of a hub plate on the top.

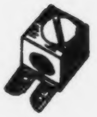
Figure 10



5. **Load center accessories and their uses**

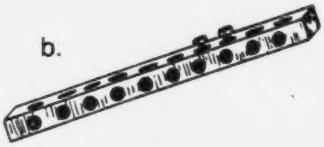
a. **Lug** — Used for termination of conductors

a.



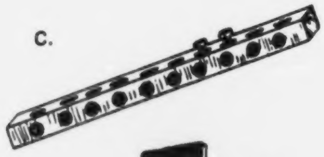
b. **Grounded (neutral) bar** — Used for termination of circuit grounded conductors

b.



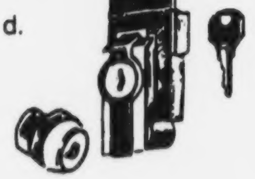
c. **Grounding bar** — Used for termination of equipment grounding conductors

c.



d. **Flush locks** — Used for locking of cabinet doors to allow entrance of qualified personnel only

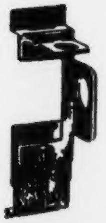
d.



Information Sheet

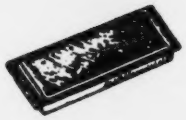
e. **Padlock attachment** — Used to lock breakers in the "off" or "on" position

e.



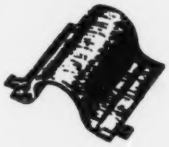
f. **Closure plate** — Used to fill empty breaker spaces where "breakouts" have been removed

f.



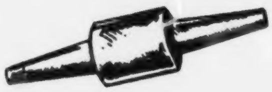
g. **Lock off** — Used to lock breakers in the "off" position for equipment maintenance or servicing

g.



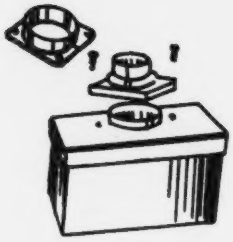
h. **Handle tie** — Used to mechanically tie two or more breaker handles together to assure common tripping

h.



i. **Conduit hubs** — Used to allow entrance of conduits to rain-proof enclosures

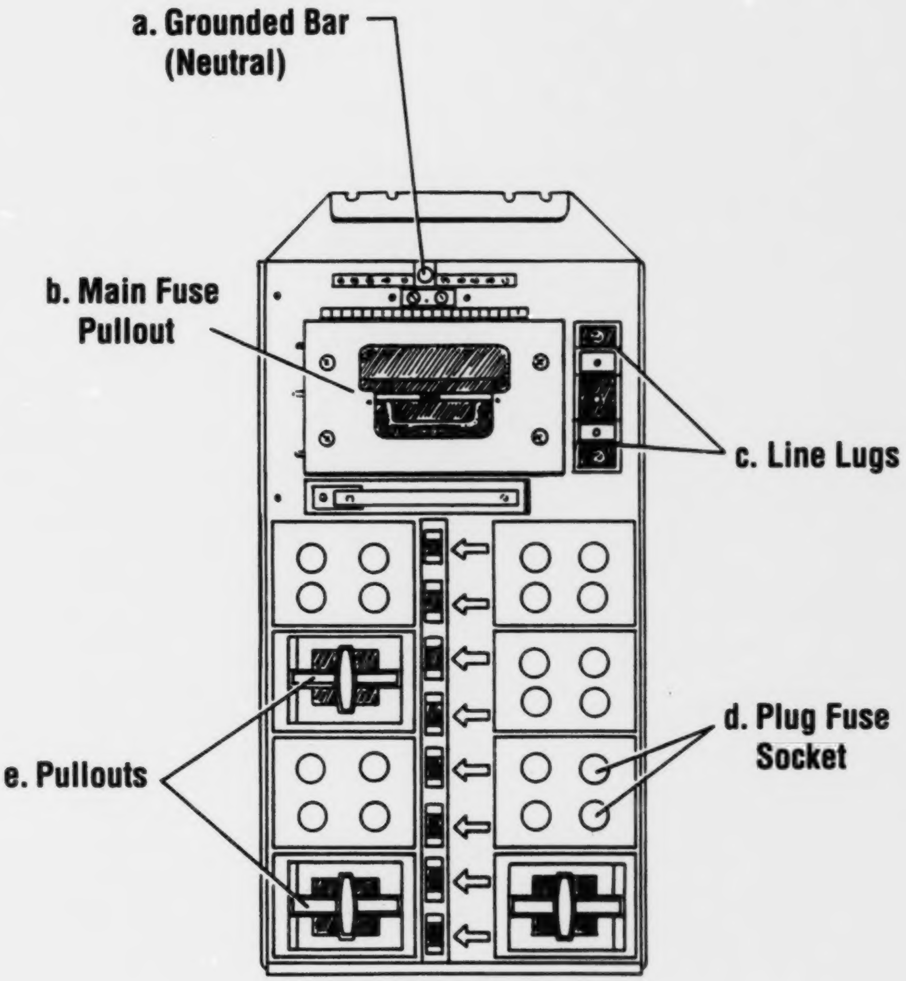
i.



Information Sheet

6. **Parts of a fusible load center** (Figure 11)

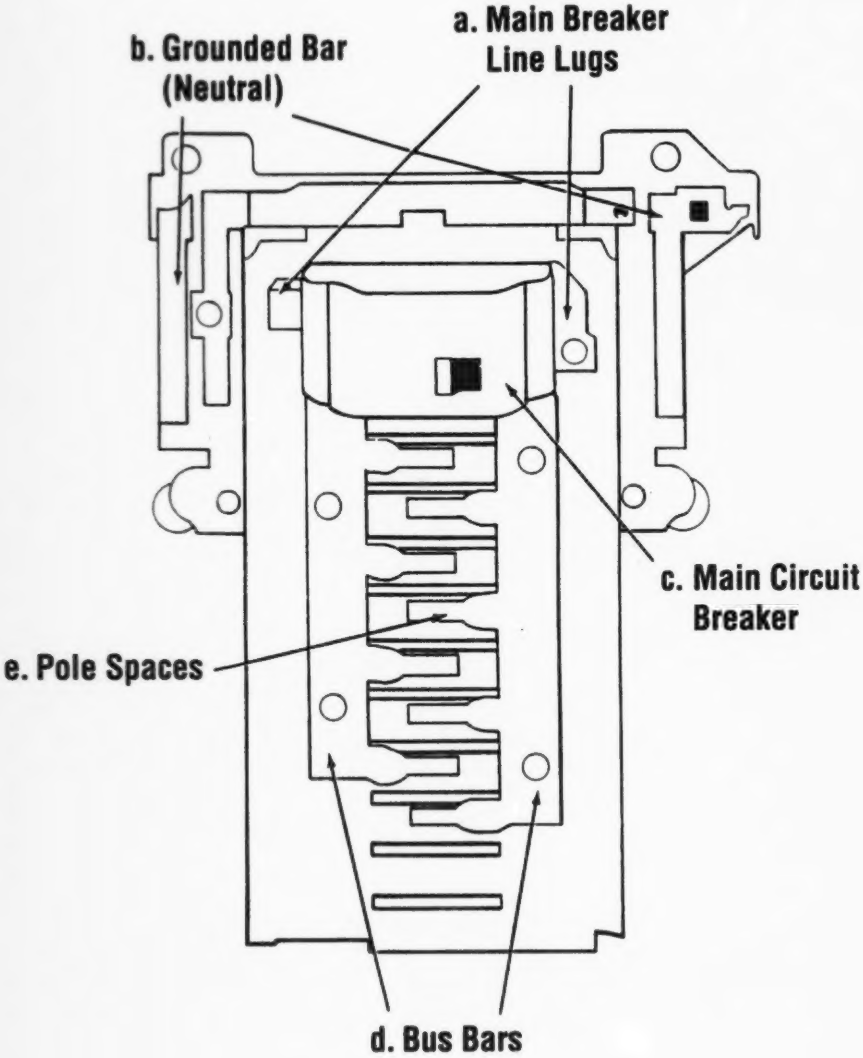
Figure 11


a. Grounded Bar (Neutral)
b. Main Fuse Pullout
c. Line Lugs
d. Plug Fuse Socket
e. Pullouts

Information Sheet

7. **Parts of a breaker load center** (Figure 12)

Figure 12

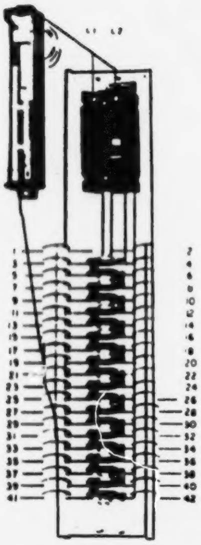

a. Main Breaker Line Lugs
b. Grounded Bar (Neutral)
c. Main Circuit Breaker
e. Pole Spaces
d. Bus Bars

Information Sheet

8. **Common panel bus configurations** (Figures 13-17)

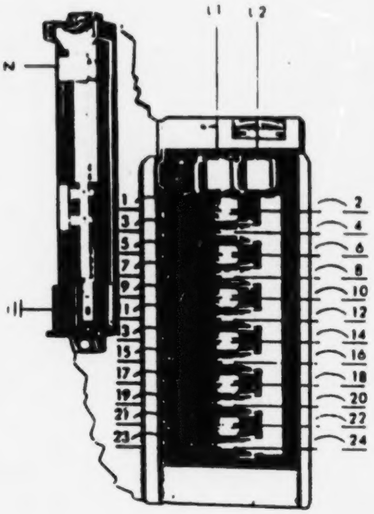
A. Main breaker single phase

Figure 13



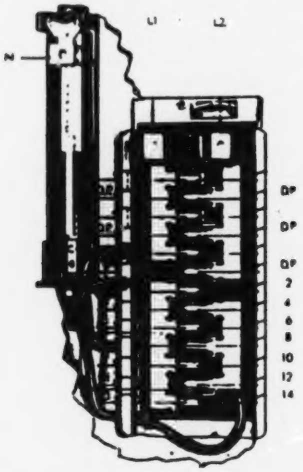
B. Main lug only (MLO) single phase

Figure 14


L1
L2
N
1
3
5
7
9
11
13
15
17
19
21
23
2
4
6
8
10
12
14
16
18
20
22
24

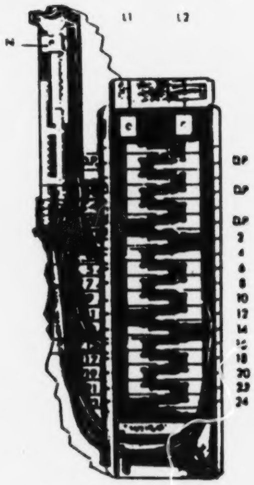
C. Split bus single phase
(existing installations only)

Figure 15


N
L1
L2
DP
DP
DP
2
4
6
8
10
12
14

D. Double split bus single phase

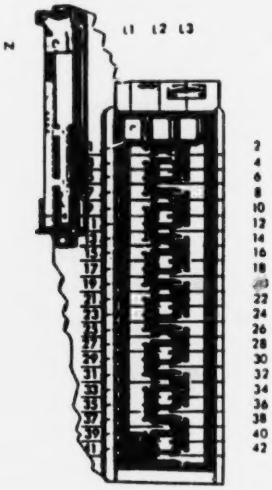
Figure 16


N
L1
L2
DP
DP
DP

Information Sheet

E. Three-phase MLO

Figure 17


N
L1 L2 L3
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42

9. Safety rules for working near load center and safety switches

a. Do not tamper with or alter equipment.

b. Install for intended purpose.

c. Install according to *NEC*.

d. Do not hold extra tools in your hand during installation or maintenance.

e. Stand to the side of a disconnect before energizing it.

Load Centers and Safety Switches
Unit 15

Assignment Sheet 1—Using the *NEC*, Answer Questions Related to Load Centers

Name ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
Assignment answers complete	_____
Minimum of seven of eight answers correct per Answer to Assignment Sheet 1	_____

Note: A load center may be considered a switchboard, panelboard, or distribution board.

Directions: Answer the following questions related to load centers. Use the *National Electrical Code*, Article 384, and state the code reference number.

A. Is it necessary to have a dedicated room for the location of load centers?

____

Code Reference ______________

B. What code articles reference to this type of equipment?

____

Code Reference ______________

C. What is the minimum wire bending space for a load center with one 2/0 conductor per terminal?

____

Code Reference ______________

____

D. What is the maximum number of overcurrent devices allowed in any one panelboard?

____

Code Reference ______________

Assignment Sheet 1

E. May a NEMA 1 load center enclosure be installed in a wet location?

____

Code Reference ________________

____

F. May the grounding bar of a load center, serving as a subpanel, be connected to the neutral bar?

____

Code Reference ________________

G. Is a deadfront required on a load center in a residential dwelling?

____

Code Reference ________________

H. What is the minimum front working space required for a load center of less than 600 volts.

____

Code Reference ________________

____

Load Centers and Safety Switches
Unit 15

Job Sheet 1—Install a Safety Switch

Name ______________________________ Attempt Number __________

Date ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
Gathered and used appropriate equipment and materials	______
Performed procedure safely	______
Performed all steps in procedure	______
Cleaned work area	______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the above criteria.

A. Equipment and materials

General-duty safety switch (indoor or raintight, three-pole, four-wire, three- fuse switch, 250-volt, 60 ampere rating
Pouch tools
Piece of #6 insulated wire, 10 feet long
Six #10 sheet metal screws, ¾-inch long
Backboard and mounting screws
Three FRNR fuses, 60 amperes
Level
Two EMT conduit connectors, 1-inch diameter
Folding rule

B. Procedure

☐ 1. Determine exact installation location.

☐ 2. Install a mounting screw for the top mounting hole.

☐ 3. Hang switch box on the screw.

Note: The hole in the upper middle back of the housing should slip over the screw head.

Job Sheet 1

☐ 4. Level the box.

☐ 5. Locate holes for the remaining two mounting screws.

☐ 6. Install the lower two mounting screws.

Note: Be sure that box is level.

☐ 7. Open 1-inch knockout holes in top and bottom of switch housing.

☐ 8. Install a 1-inch EMT connector in each knockout hole.

☐ 9. Cut six 12-inch lengths of #6 wire.

☐ 10. Strip back one end of each piece of wire about ⅝ inch.

☐ 11. Install three #6 wires through the 1-inch connector in the top of the switch housing, and connect to terminals L1, L2, and L3.

Note: Install the wires neatly, taking care to prevent the wires from rubbing against any metal edge.

☐ 12. Firmly tighten terminals, L1, L2, and L3 to manufacturer's torque specifications.

Caution: Loose connections are a chief cause of electrical problems.

☐ 13. Install three pieces of #6 wire through the 1-inch connector in the bottom of the switch housing, and connect to load terminals T1, T2, and T3.

Note: Install the wires neatly, taking care to prevent the wires from rubbing against any metal edge.

☐ 14. Firmly tighten terminals T1, T2, and T3 to manufacturer's torque specifications.

☐ 15. Determine length of ground wire by measuring from top of box to ground terminal.

☐ 16. Cut a piece of #6 wire to the measured length.

☐ 17. Strip back the lower end of the ground wire; install in the ground terminal and tighten.

Job Sheet 1

☐ 18. Install ground wire through bottom hole in switch housing.

☐ 19. Form the ground wire neatly so that it will not touch any moving part of the switch.

☐ 20. Strip back upper end of ground wire; install ground wire in switch terminal and tighten.

☐ 21. Insert the three 60-amp fuses into the fuse clips.

Note: Fuse clips must fit tightly on each fuse. Have instructor evaluate your work. If installation is satisfactory, it may be used for completing Job Sheet 2.

☐ 22. Clean work area, and return equipment and materials to proper storage.

Evaluator's comments: ______________________________

____

____

Load Centers and Safety Switches
Unit 15

Job Sheet 2—Wire a Load Center or Breaker Panel

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation criteria	**Rating**
Gathered and used appropriate equipment and materials	_____
Performed procedure safely	_____
Performed all steps in procedure	_____
Cleaned work area	_____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the above criteria.

A. Equipment and materials

Single-phase load center, 100 amperes
Two 2-pole breakers, 30 amperes
Two single-pole breakers, 30 amperes
Eight single-pole breakers, 20 amperes
Studs or backboard for mounting panel
Four #10 sheetmetal mounting screws, ¾ inch long
Two pieces of #2 insulated copper wire, 30 inches each
Piece of #2 insulated copper wire, 60 inches long
Seven pieces of #10 insulated wire, 5 feet each (color other than green or white)
Eight pieces of #12 insulated wire, 6 feet each (color other than green or white)
Eight pieces of green #12 insulated wire, 6 feet each
Eight pieces of white #12 insulated wire, 6 feet each
Four pieces of green #10 insulated wire, 6 feet each

Note: Length of ground wire may vary depending on location of the ground bar. Use good judgment in cutting wire lengths.

Pouch tools
White or gray phasing tape
Compression-type EMT connector, 1¼-inch diameter
Twelve compression-type EMT connectors, ½-inch diameter
Compression-type EMT connector, ¾-inch diameter
Breaker index sheet
Piece of #4 bare wire 3 feet long for use as a grounding electrode conductor

Job Sheet 2

B. Procedure

☐ 1. Before mounting panel, open twelve ½-inch knockout holes, one ¾-inch knockout hole, and one 1¼-inch knockout hole for EMT conduit.

Note: The 1¼-inch knockout hole will generally be located in the center of the top of the panel. The ½-inch and ¾-inch knockouts may be located in the top or bottom, or both top and bottom.

☐ 2. Install the ½-inch and ¾-inch EMT connectors; tighten snugly.

☐ 3. Install the 1¼-inch EMT connector; tighten snugly.

☐ 4. Mount panelboard in designated location.

☐ 5. Connect one end of the #4 bare ground wire to the ground bar, allowing other end to hang from bottom of panel.

Note: Under actual installation, the lower end of the ground wire would terminate at the grounding electrode.

☐ 6. Strip back one end of each piece of insulated wire approximately ⅝ to ¾ inch.

☐ 7. Install one piece of #2 wire through the 1¼-inch connector to the neutral bar connector; arrange the wire neatly to lay in back corner of the panel; then insert wire in neutral bar terminal and tighten snugly.

Note: The neutral conductor should lay in the back corner of the panel to leave adequate room for the other wires and breakers. It should also be identified by white or gray tape.

☐ 8. Install the remaining two wires through the 1¼-inch connector, and insert wires in the main breaker connectors.

Note: Arrange wires neatly, allowing room for the branch-circuit conductors.

☐ 9. Plug the two 2-pole breakers into the panel bus, one breaker on the right, the other on the left at the top positions.

☐ 10. Plug the two single-pole, 30 amp breakers into the panel bus, one breaker on the left, the other on the right in the top positions.

☐ 11. Plug the eight single-pole breakers into the panel bus, four breakers on the left, and four on the right in the remaining positions.

Job Sheet 2

12. Install remaining wires.

    ☐ a. For the two-pole breakers, insert two #10 colored wires (other than green or white) and one #10 green wire through the ¾-inch connector.

    Note: Extend all wires into the panel far enough to reach the neutral or ground bar, especially the green wire after arranging it in the back corner of panel down to ground bar.

    ☐ b. For the single-pole, 30-amp breakers, insert two #10 colored and one #10 green wire for each breaker.

    ☐ c. For the single-pole breakers, insert one #12 colored, one #12 white for neutral, and one #12 green wire for each breaker.

☐ 13. Tag or mark by number each group of wires that goes to a specific breaker.

☐ 14. Fold back out of the way all branch circuit wires inside the panel to provide clear working space inside panel.

15. Trim out panelboard.

    ☐ a. Work the green wires one at a time, arranging them against back of panel in corners and making right angle bends to the ground bar terminals.

    ☐ b. Cut, strip, and insert wires into terminals; tighten snugly.

    Note: This method places this group of wires in the back of the panel, out of the way of neutral and circuit wires; also, it gives the technician an organized procedure for doing the work neatly.

    ☐ c. Work the white neutral wires one at a time, laying the wires near the green wires in the back spaces and corners of the panel and making bends to the neutral or ground bar.

    ☐ d. Cut, strip, and insert wires into terminals; tighten snugly.

e. Work the colored circuit wires.

☐ (1) Work the #10 wires one at a time to the left two-pole breaker, forming the wire to lay neatly toward the back and side of panel; make right-angle bends to bring wire horizontally toward proper breaker terminal; make additional right-angle bends to bring wires outward and then into breaker.

Note: This procedure makes it easy to trace wires, provides enough wire length to pull out and check loads with a clamp-on ammeter, and produces a neat, professional-looking job.

☐ (2) Work the #10 wires to the right two-pole breaker, using the procedure outlined in Step e(1).

☐ (3) Work the wires to the single-pole 30 amp breakers, using the procedure outlined in Step e(1).

☐ (4) Work the single-pole circuit wires, making neat bends and using the same procedure outlined in Step e(1).

☐ f. Double-check to make sure that all connections make good contact and are tightened to manufacturer's torque specifications.

Note: Have instructor evaluate your work.

☐ 16. Carefully dismantle the assembly and store parts in proper places.

☐ 17. Clean work area, and return equipment and materials to proper storage.

Evaluator's comments: ______________________________

____

____

Load Centers and Safety Switches
Unit 15

Job Sheet 3—Wire a Receptacle Circuit to a Load Center

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation criteria	**Rating**
Gathered and used appropriate equipment and materials	______
Performed procedure safely	______
Performed all steps in procedure	______
Cleaned work area	______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the above criteria.

A. Equipment and materials

- Pouch tools
- ½-inch drill motor
- ½-inch chip auger
- Romex staples
- 15-foot 12/2 with ground NMB
- Three plastic 1-gauge nailup device boxes
- 4-foot 10/3 with ground
- Three 15-amp 125-volt duplex receptacles
- 2- or 4-circuit load center
- One 20-amp single-pole breaker
- Two ½-inch Romex connectors
- Four #10 × 1 sheetmetal screws
- *NEC*

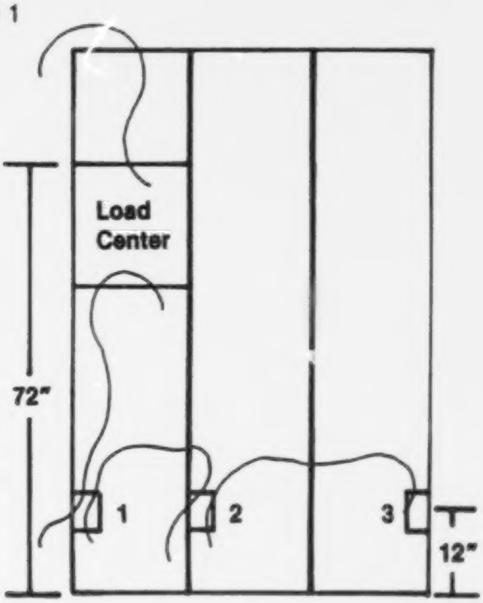
Job Sheet 3

B. Procedure

☐ 1. Mark and lay out boxes according to drawing. (Figure 1)

Note: Be sure to check the *NEC* for installation of NM cable.

Figure 1



☐ 2. Mount device boxes for ½-inch Sheetrock®.

☐ 3. Mount load center for flush installation (½-inch Sheetrock).

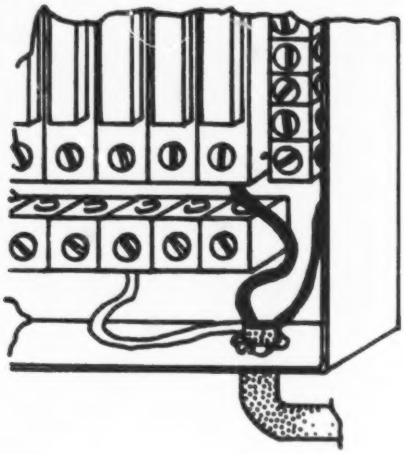
☐ 4. Drill studs according to cable layout and *NEC.*

☐ 5. Route cable through studs, and support properly.

Job Sheet 3

☐ 6. Install Romex connector in bottom of load center and install cable. (Figure 2)

Figure 2



☐ 7. Strip sheath from cables in device boxes.

Note: Be sure that at least 6 inches of conductor leaves the face of the box.

☐ 8. In boxes 1 and 2, twist grounds together and install a green wire nut, leaving enough pigtail to terminate on receptacle grounding terminal.

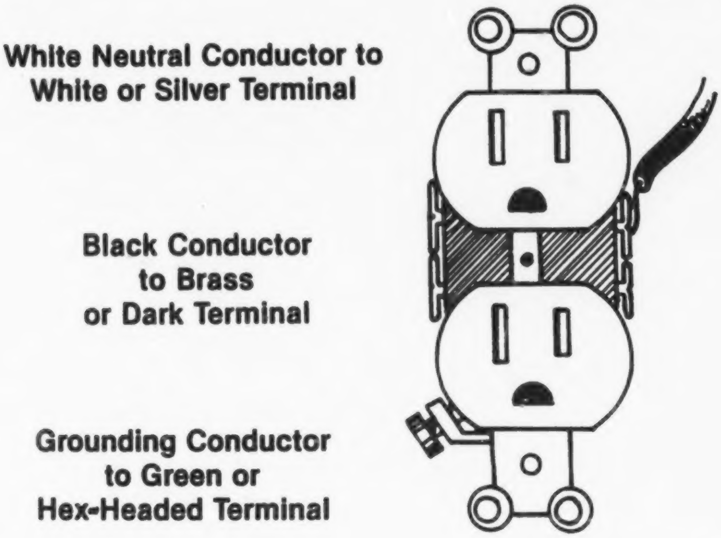
☐ 9. Strip ½-inch of insulation from neutral (white) conductors and twist in a 6-inch pigtail; install a red wire nut over joint.

Job Sheet 3

☐ 10. Terminate all conductors according to instructor's demonstration. (Figure 3)

Note: Methods may vary due to local codes.

Figure 3


White Neutral Conductor to White or Silver Terminal
Black Conductor to Brass or Dark Terminal
Grounding Conductor to Green or Hex-Headed Terminal

☐ 11. Install Romex connector in top of load center and terminate the 10/3 with ground as the feeder conductors.

☐ 12. Double check to make sure all terminations are tight.

Note: Have instructor evaluate your work.

☐ 13. Carefully dismantle the assembly and store parts in proper places.

☐ 14. Clean work area, and return equipment and materials to proper storage.

Evaluator's comments: ____

____

____

Existing Structures
Unit 16

Objective Sheet

Unit Objective

After completing this unit, the student should be able to determine the number of conductors allowed in an existing conduit and install additional box locations and cable runs in existing structures. The student should demonstrate these competencies by completing the assignment and job sheets and scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to existing structures with their correct definitions.
2. Identify construction members common in existing structures.
3. List four common routes for new cable installations in existing structures.
4. Complete a list of possible methods for getting cable through or around construction members.
5. List five wall or ceiling compositions that may be found in an existing structure.
6. Complete statements about conditions for using optional calculations for additional loads to existing installations.
7. List exceptions to the *NEC* requirements for support of flexible metal conduit.
8. Arrange in order the steps for determining the number of conductors allowed in a conduit, based on cross-sectional area.
9. Determine the number of conductors allowed to be added to an existing conduit. (Assignment Sheet 1)
10. Install a box with dry-wall grips in a plasterboard wall. (Job Sheet 1)
11. Secure a box with dry-wall supports (box tins). (Job Sheet 2)
12. Install a box in a lath and plaster wall. (Job Sheet 3)
13. Install a box in a paneled wall. (Job Sheet 4)

Objective Sheet

14. Install a box in a concrete block wall. (Job Sheet 5)

15. Install a box in a brick wall. (Job Sheet 6)

16. Install a box in a ceiling with an accessible attic. (Job Sheet 7)

17. Install cable between an existing box and a newly installed box horizontally along a wall in a channel behind bare board. (Job Sheet 8)

18. Install cable between an existing box and a newly installed box, using an underfloor crawl space. (Job Sheet 9)

19. Install cable between an existing box and a newly installed box, using attic space. (Job Sheet 10)

Existing Structures
Unit 16

Suggested Activities

Instructional Plan

Preparation

1. Read the unit carefully and plan for instruction. Study the specific objectives to determine the order in which you will present them.

2. Review Teaching Suggestions section that follows. Plan for classroom activities.

3. Plan your presentation to take advantage of student learning styles and to accommodate special needs students.

4. Make transparencies from the transparency masters included with this unit. These appear in the teacher edition only and are designed to be used with the following objectives:

   TM 1—Construction Members (Objective 2)
   TM 2—Construction Members (Continued)
   TM 3—Common Routes for New Cable Installations (Objective 3)
   TM 4—Common Routes for New Cable Installations (Continued)
   TM 5—Working Past Fire Stops (Objective 4)
   TM 6—Working Past Fire Stops (Continued)

5. Obtain films, videotapes, and other resources to supplement instruction of this unit. See ordering information in the Suggested Supplemental Resources section that follows.

6. Develop teaching plan. Adjust for different learning styles.

7. Make copies of Unit Evaluation Form.

8. Coordinate an activity with the carpentry instructor or an outside contractor to construct a trainer wall with the necessary wall coverings for this unit.

9. Coordinate an activity with the masonry instructor or an outside contractor to construct a trainer wall of both brick and concrete block.

Suggested Activities

Delivery and Application

10. Provide students with unit of instruction.

11. Discuss unit and specific objectives.

12. Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.

13. Discuss the assignment sheets and schedule due date. Review criteria for evaluation of these activities.

14. Discuss and demonstrate the job sheets. Review criteria for evaluation of these activities.

Evaluation

15. Discuss the use of the Unit Evaluation Form with students. Discuss the rating scale that will be used for student evaluation.

16. Make copies of the written test. Add or modify test items as needed.

17. Give written test.

18. Compile assignment and job sheet ratings and written test scores on the Unit Evaluation Form. Add any additional assignments or supplemental activities that should be part of the unit evaluation.

19. Reteach and retest as required.

Teaching Suggestions

Note: Skill areas appearing in boldface type in the Teaching Suggestions refer to the academic and workplace skills identified by the American Society for Training and Development (ASTD) and the U.S. Department of Labor. These have been adapted by MAVCC.

1. Explain fishing techniques in two-story houses. Skill area: **Listening**

2. Take a field trip to a remodeled or old house with exposed construction members.

3. Visit a local electrical remodel job on a commercial building.

4. Have a local inspector visit the class and discuss remodel work. Skill area: **Listening**

Suggested Activities

5. Discuss possible problems that can arise in cutting boxes in existing walls. Skill area: **Listening**

6. Demonstrate knife scoring techniques for cutting a box opening in plasterboard. Allow students to return your demonstration. Skill area: **Listening, applying principles**

Resources Used in Developing This Unit

1. Earley, Mark W., John M. Caloggero, and Richard H. Murray. *National Electrical Code 1993*. Quincy, MA: National Fire Protection Association, 1992.

2. Taylor, Mark. *Residential Wiring*. Revised. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1983.

Instructions for Evaluating Student Performance

Assignment Sheets—Be sure the student understands the criteria on which the evaluation is based. Assign a point value to each criterion and convert the total points to a percentage for grading.

Job Sheets—Be sure the student understands the criteria on which the evaluation is based. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in either the teacher edition or student manual. Then observe the student performing the procedure. Rate both process and product.

> Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily achieved the step(s) for each checkpoint area. If the student is unable to correctly complete the procedure, have the student review the materials and try again.
>
> Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria which have been provided as part of the job sheet. Complete the rating by assigning a point value to each criterion and by converting the point total to a percentage for grading. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) which best fits your program needs.

Option A

4 - Skilled—Can perform job with no additional training.
3 - Moderately skilled—Has performed job during

Option B

Yes—Can perform job with no additional training.

training program; limited additional training may be required.

2 - Limited skill—Has performed job during training program; additional training is required to develop skill.

1 - Unskilled—Is familiar with process, but is unable to perform job.

No—Is unable to perform job satisfactorily.

Existing Structures
Unit 16

Answers to Assignment Sheet 1

A. .21 sq. in. conduit area
.0311 sq. in. #10 THW

.0311
× 6
.1866 sq. in.

.1866 is less than .21; therefore, the additional wires are allowed.

B. .12 sq. in. conduit area
.0117 sq. in. #12 THHN

.0117
× 7
.0819 sq. in.

.0819 is less than .12; therefore, the additional wires are allowed.

C. .82 sq. in. conduit area
.2367 sq. in. for I/O THW
.0519 sq. in. for #6 THHN

.2367
× 3
.7101 sq. in.

.0519
× 3
.1557 sq. in.

.7101
+.1557
.8658 sq. in.

.8658 is greater than .82; therefore, a new conduit must be run.

Existing Structures
Unit 16

Answers to Written Test

1. a. 2
   b. 6
   c. 7
   d. 12
   e. 8
   f. 10
   g. 5
   h. 11
   i. 1
   j. 3
   k. 4
   l. 9

2. a. Fire stop
   b. Header
   c. Sill
   d. First floor joists
   e. Plate
   f. Stud
   g. Brace
   h. Sleeper wall
   i. Rafter
   j. Ridge board
   k. Top plate
   l. Ceiling joists
   m. Flooring
   n. Bridging
   o. Subfloor
   p. Bottom plate (sole plate)
   q. Girder
   r. Pier block
   s. Girder post
   t. Pier
   u. Foundation wall
   v. Footing

3. a. Vertically in a wall
   b. Horizontally in a channel behind baseboard
   c. Horizontally in underfloor crawl space
   d. Horizontally in an attic

4. a. (1) Straight
      (2) Angle
      (3) Shingle
      (4) Top plate
   b. (1) Top
      (2) Bottom
   c. (1) Top
      (2) Removal
      (3) Channeling

Answers to Written Test

5. a. Plasterboard
   b. Lath and plaster
   c. Paneling
   d. Concrete block
   e. Brick

6. a. 1 year
   b. Rating
   c. Overcurrent protection

7. Answer should include any two of the following:

   a. Where flexible metal conduit is fished
   b. Lengths not exceeding 3 feet
   c. Lengths not exceeding 6 feet from a fixture terminal connection for tap connections to lighting fixtures as required in 410-67(c)

8. a. 4
   b. 1
   c. 5
   d. 3
   e. 2

Existing Structures
Unit 16

Written Test

Name ________________________________ Score ______________

1. Match terms related to existing structures with their correct definitions. Write the correct numbers in the blanks.

______a. Groove formed in materials

______b. Establishing a connection between two points so that a cable can be installed

______c. Length of wire with a hook formed in one end to catch materials being fished in a space

______d. Working space underneath the house

______e. Old method for covering interior walls; small strips of wood spaced evenly over studs to support and hold plaster

______f. Flat sheet used in construction as a wall covering; it has an outer covering of felt sandwiching a gypsum plaster core

______g. Cloth used to catch falling debris from cutting or chipping work

______h. Compass-type tool that uses a magnet to find nails and thus indicate stud locations

______i. Piece of brick

______j. Area in square inches allowed in a conduit or tubing; area required for conductors in a conduit or tubing

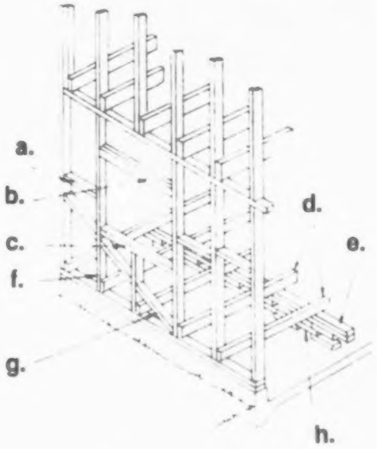
______k. Short length of small chain used to pull conductors or flexible conduit through an enclosed space or wall cavity

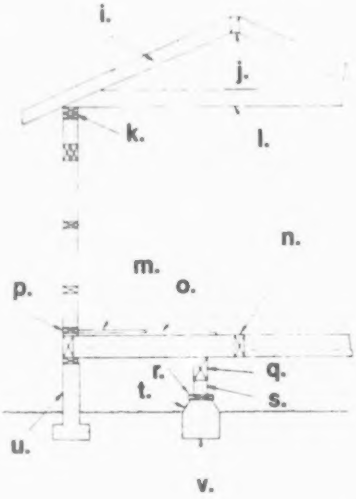
______l. Usually, a vertical space between two floors, dedicated for the running of pipes and conduits between floors

1. Brick bat
2. Channel
3. Cross sectional area
4. Drop chain
5. Drop cloth
6. Fish
7. Fish wire
8. Lath and plaster
9. Pipe chase
10. Plasterboard (Sheetrock®)
11. Stud finder
12. Underfloor crawl space

Written Test

2. Identify the construction members common in existing structures shown in the two illustrations below. Write the correct names in the blanks.




i.
j.
k.
l.
n.
m.
o.
p.
r.
q.
t.
s.
u.
v.

______a. ____________________

______b. ____________________

______c. ____________________

______d. ____________________

______e. ____________________

______f. ____________________

______g. ____________________

______h. ____________________

______i. ____________________

______j. ____________________

______k. ____________________

______l. ____________________

______m. ____________________

______n. ____________________

______o. ____________________

______p. ____________________

______q. ____________________

______r. ____________________

______s. ____________________

______t. ____________________

______u. ____________________

______v. ____________________

Written Test

3. List four common routes for new cable installations in existing structures.

   a. ______________________________

   b. ______________________________

   c. ______________________________

   d. ______________________________

4. Complete the following list of possible methods for getting cable through or around construction members. Write in the blanks the word(s) that best completes the list.

   a. Top plates

      (1) ______________ drilling

      (2) ______________ drilling

      (3) Lifting a ______________ and drilling

      (4) Over ______________ ______________ and back through insulation board inside eave

   b. Bottom plates (sole plate)

      (1) ______________ drilling behind baseboard

      (2) ______________ drilling

   c. Fire stops

      (1) Lifting shingle and ______________ drilling through block with extension

      (2) Top drilling with door trim and baseboard ______________

      (3) Top drilling and ______________ past

5. List five wall or ceiling compositions that may be found in an existing structure.

   a. ______________________________

   b. ______________________________

   c. ______________________________

   d. ______________________________

   e. ______________________________

Written Test

6. Complete the following statements about conditions for using optional calculations for additional loads to existing installations. Write in the blanks the word(s) that best completes each statement.

   a. The maximum demand data is available in KVA for a minimum of a ____________________ period.

   b. The existing demand at 125 percent plus the new load does not exceed the ampacity of the feeders or ____________________ of the service.

   c. The feeder or service has ____________________ in accordance with sections 230-90 and 240-3 of the *NEC*.

7. List two exceptions to the *NEC* requirements for support of flexible metal conduit.

   a. ____

   ____

   ____

   b. ____

   ____

   ____

8. Arrange in order the steps for determining the number of conductors allowed in a conduit, based on cross-sectional area. Write a "1" before the first step, a "2" before the second step, and so on.

   ______a. Compute total area occupied by existing conductors, based on Table 5, Chapter 9 of the *NEC*.

   ______b. Determine size of existing conduit.

   ______c. Determine number of conductors that may be added.

   ______d. Find area of conduit or tubing, using Table 4, Chapter 9 of the *NEC*.

   ______e. Determine number and size of existing conductors.

***Permission to duplicate this test is granted.**

Existing Structures
Unit 16

Unit Evaluation Form

Student Name ______________________ Unit Rating __________

Assignment Sheet 1—Determine the Number of Conductors Allowed to be Added to an Existing Conduit Rating ______

Comments: ______________________

Job Sheet 1—Install a Box with Dry-Wall Grips in a Plasterboard Wall Rating ______

Comments: ______________________

Job Sheet 2—Secure a Box with Dry-Wall Supports (Boxtins) Rating ______

Comments: ______________________

Job Sheet 3—Install a Box in a Lath and Plaster Wall Rating ______

Comments: ______________________

Job Sheet 4—Install a Box in a Paneled Wall Rating ______

Comments: ______________________

Job Sheet 5—Install a Box in a Concrete Block Wall Rating ______

Comments: ______________________

Job Sheet 6—Install a Box in a Brick Wall Rating ______

Comments: ______________________

Unit Evaluation Form

Job Sheet 7—Install a Box in a Ceiling with an Accessible Attic Rating ______

Comments: ______

Job Sheet 8—Install Cable Between an Existing Box and a Newly Installed Box Horizontally Along a Wall in a Channel Behind Bare Board Rating ______

Comments: ______

Job Sheet 9—Install Cable Between an Existing Box and a Newly Installed Box, Using an Underfloor Crawl Space Rating ______

Comments: ______

Job Sheet 10—Install Cable Between an Existing Box and a Newly Installed Box, Using Attic Space

Rating ______

Comments: ______

Written Test Scores

Pretest ______ Posttest ______ Other ______

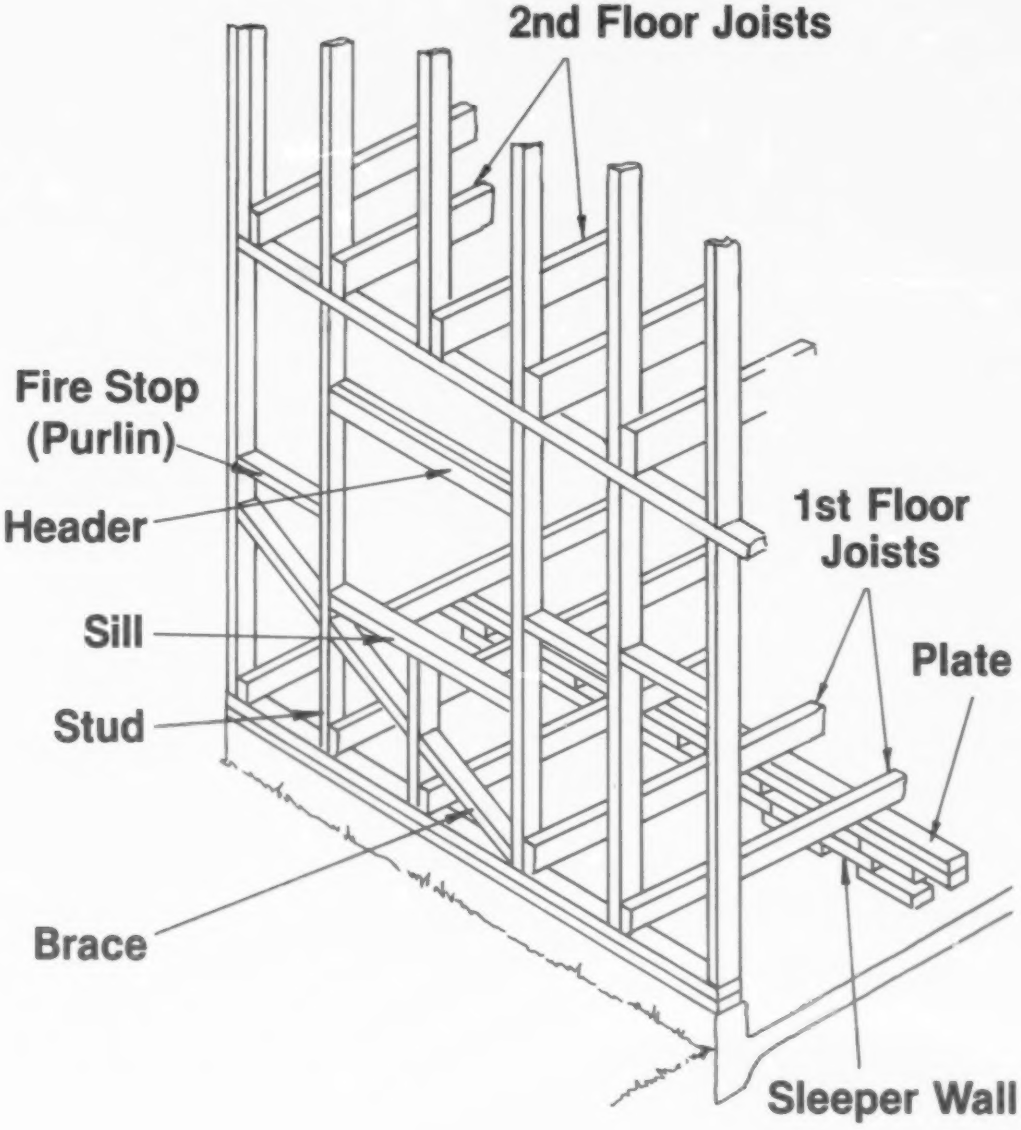
Other ______

Teacher Signature ______ Date ______

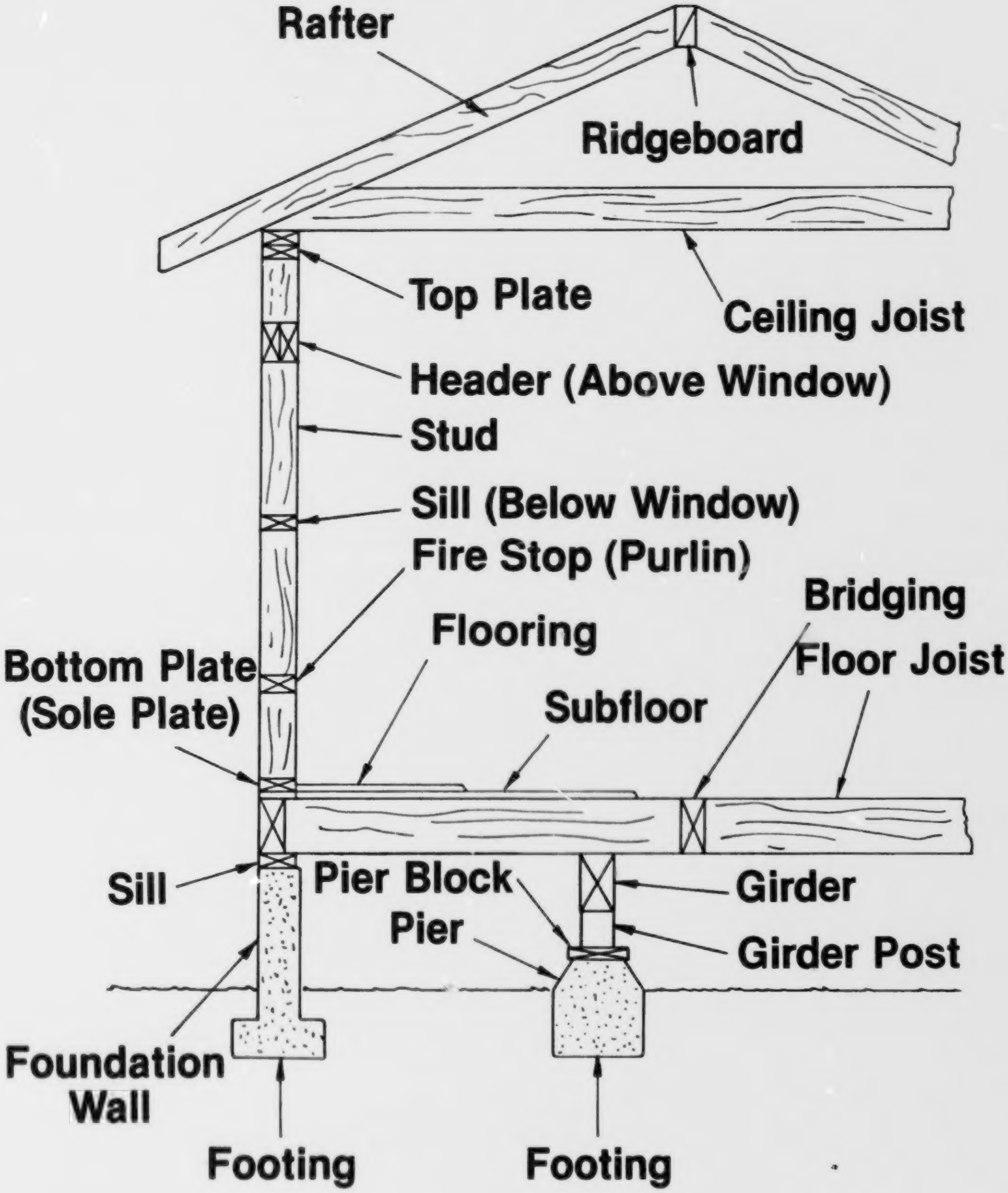
Student Signature ______ Date ______

***Permission to duplicate this form is granted.**

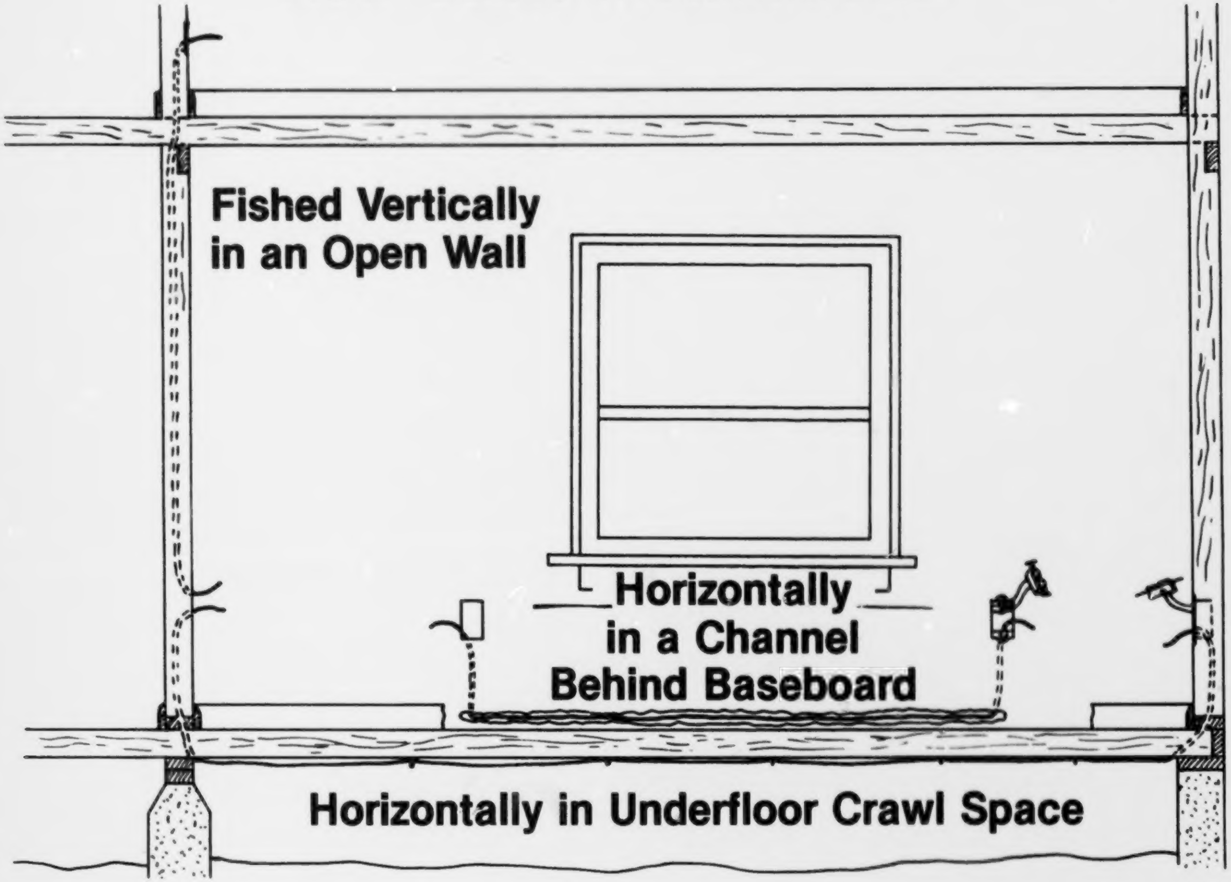
Construction Members


2nd Floor Joists
Fire Stop (Purlin)
Header
Sill
Stud
Brace
1st Floor Joists
Plate
Sleeper Wall

Construction Members (Continued)


Rafter
Ridgeboard
Top Plate
Ceiling Joist
Header (Above Window)
Stud
Sill (Below Window)
Fire Stop (Purlin)
Bridging
Flooring
Floor Joist
Bottom Plate (Sole Plate)
Subfloor
Sill
Pier Block
Girder
Pier
Girder Post
Foundation Wall
Footing
Footing

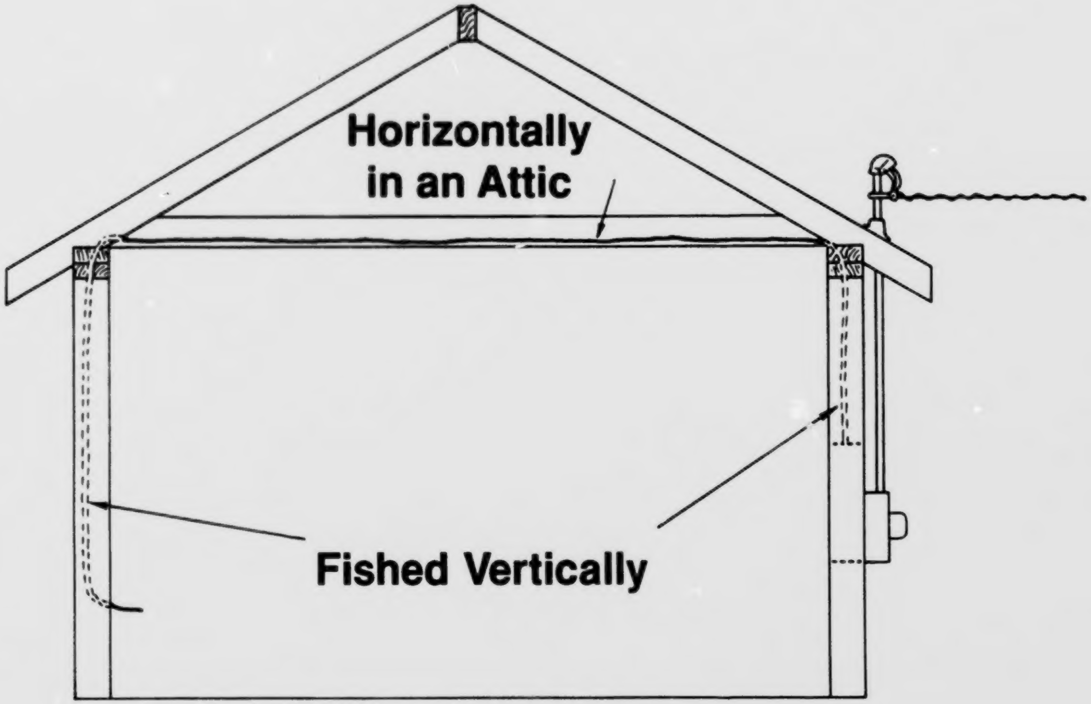
Common Routes for New Cable Installations


Fished Vertically in an Open Wall
Horizontally in a Channel Behind Baseboard
Horizontally in Underfloor Crawl Space

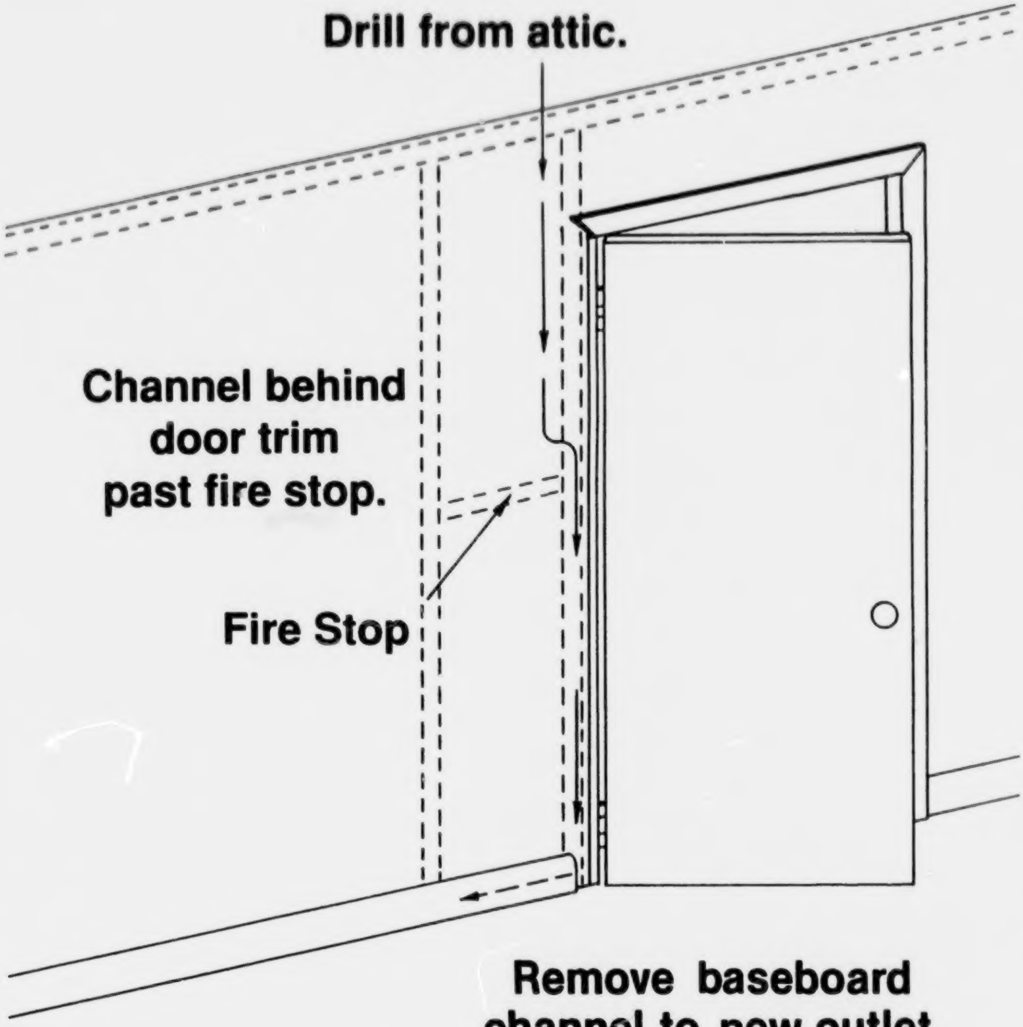
Basic Wiring, Unit 16
Teacher Page 19

TM 3

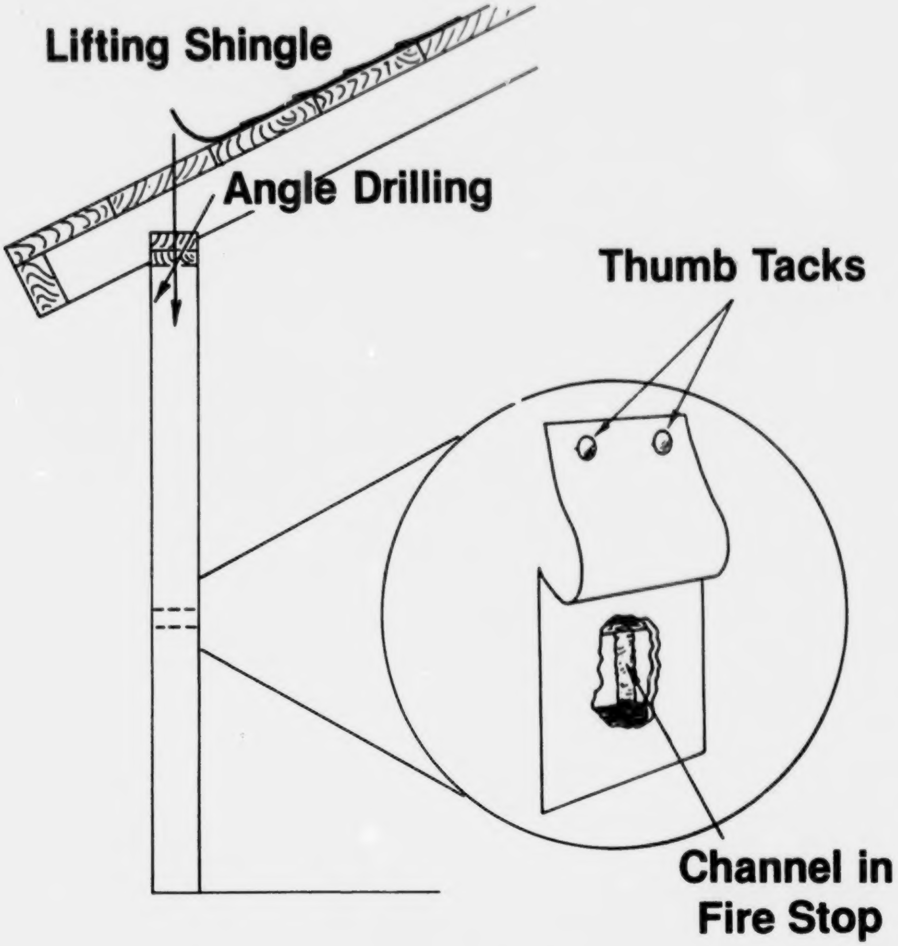
Common Routes for New Cable Installations (Continued)


Horizontally in an Attic
Fished Vertically

Working Past Fire Stops


Drill from attic.
Channel behind door trim past fire stop.
Fire Stop
Remove baseboard channel to new outlet.

Working Past Fire Stops
(Continued)


Lifting Shingle
Angle Drilling
Thumb Tacks
Channel in Fire Stop

966

Existing Structures
Unit 16

Information Sheet

1. **Terms and definitions**

    a. **Brick bat** — Piece of brick

    b. **Channel** — Groove formed in materials

    c. **Cross sectional area** — Area in square inches allowed in a conduit or tubing; area required for conductors in a conduit or tubing

    d. **Drop chain** — Short length of small chain used to pull conductors or flexible conduit through an enclosed space or wall cavity

    e. **Drop cloth** — Cloth used to catch falling debris from cutting or chipping work

    f. **Fish** — Establishing a connection between two points so that a cable can be installed

    g. **Fish wire** — Length of wire with a hook formed in one end to catch materials being fished in a space

    h. **Lath and plaster** — Old method for covering interior walls; small strips of wood spaced evenly over studs to support and hold plaster

    i. **Pipe chase** — Usually a vertical space between two floors, dedicated for the running of pipes and conduits between floors

    j. **Plasterboard (Sheetrock®)** — Flat sheet used in construction as a wall covering; it has an outer covering of felt sandwiching a gypsum plaster core

    k. **Stud finder** — Compass-type tool that uses a magnet to find nails and thus indicate stud locations

    l. **Underfloor crawl space** — Working space underneath the house

Information Sheet

2. **Construction members common in existing structures** (Figures 1 and 2)

Figure 1

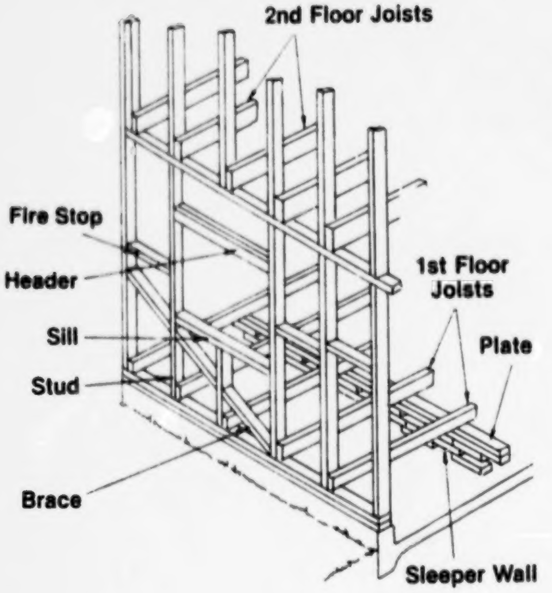
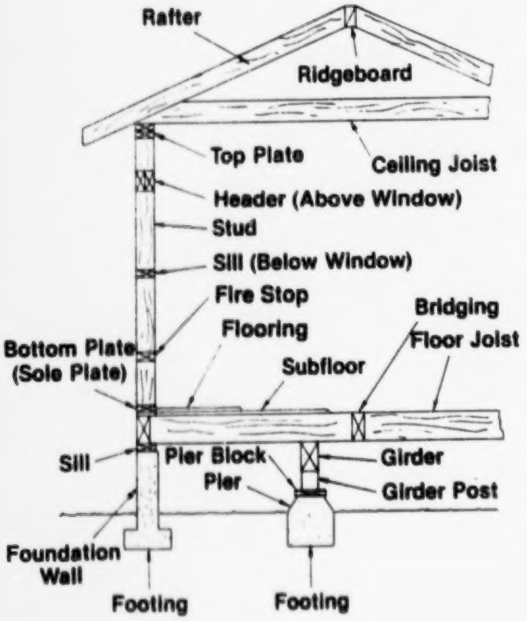

2nd Floor Joists
Fire Stop
Header
1st Floor Joists
Sill
Plate
Stud
Brace
Sleeper Wall

Figure 2


Rafter
Ridgeboard
Top Plate
Ceiling Joist
Header (Above Window)
Stud
Sill (Below Window)
Fire Stop
Bridging
Flooring
Floor Joist
Bottom Plate
(Sole Plate)
Subfloor
Sill
Pier Block
Girder
Pier
Girder Post
Foundation Wall
Footing
Footing

Information Sheet

3. **Common routes for new cable installations in existing structures** (Figures 3 and 4)

   a. Vertically in a wall

   b. Horizontally in a channel behind baseboard

   c. Horizontally in underfloor crawl space

   d. Horizontally in an attic

Figure 3

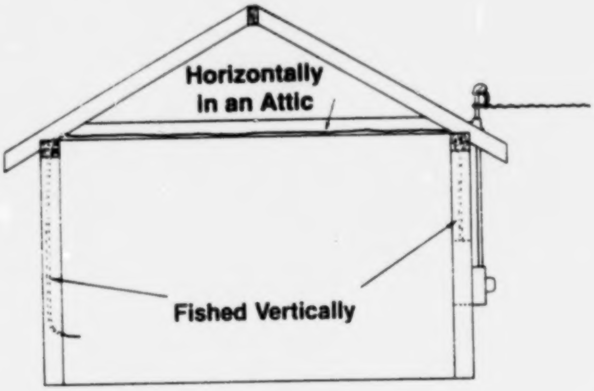
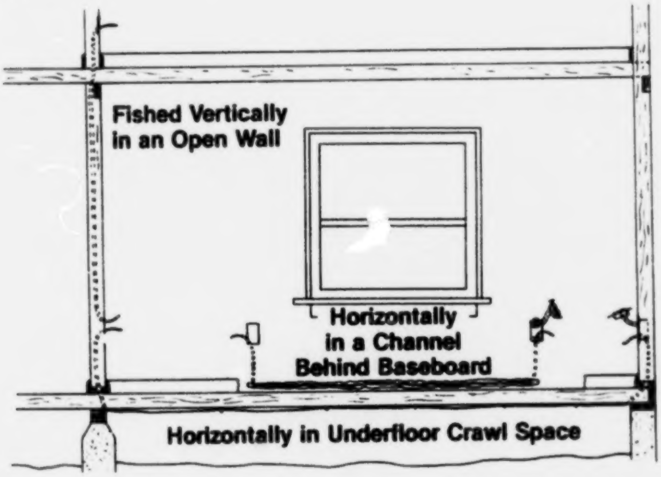

Horizontally
In an Attic
Fished Vertically

Figure 4


Fished Vertically
in an Open Wall
Horizontally
in a Channel
Behind Baseboard
Horizontally in Underfloor Crawl Space

Information Sheet

4. Possible methods for getting cable through or around construction members

Note: Good electricians can think their way around almost anything.

a. Top plates

- Straight drilling
- Angle drilling
- Lifting a shingle and drilling
- Over top plate and back through insulation board inside eave

  Note: To make a safe professional installation, select the method that is easiest and causes the least structural boring or changing.

b. Bottom plates (sole plate)

- Top drilling behind baseboard
- Bottom drilling

  Note: Bottom drilling is the preferred method because of the time involved in removal and reinstallation of baseboard.

c. Fire stops

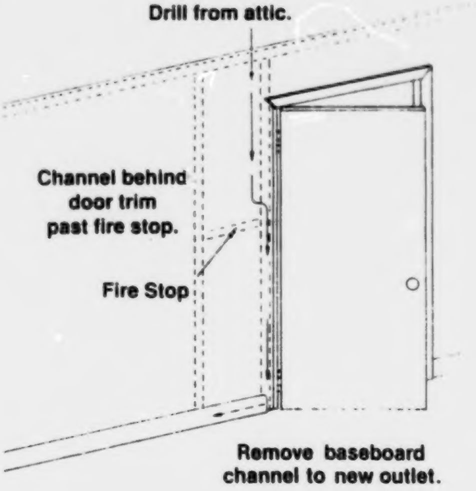
- Lifting shingle and top drilling through block with extension

  Note: This method works if the fire block is fairly high in the wall.

Information Sheet

- Top drilling with door trim and baseboard removal (Figure 5)

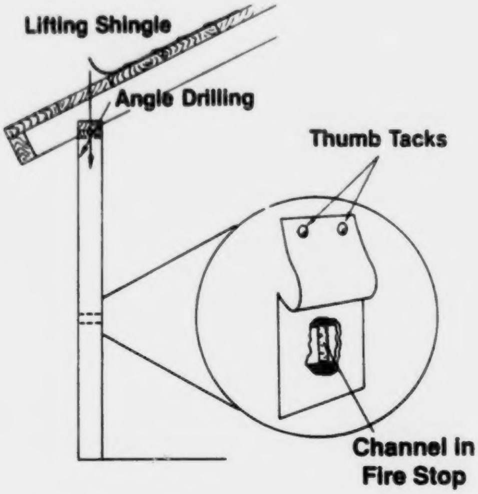
Figure 5


Drill from attic.
Channel behind door trim past fire stop.
Fire Stop
Remove baseboard channel to new outlet.

- Top drilling and channeling past (Figure 6)

Note: Be sure to smooth out your work with spackling or joint compound before laying wallpaper back down.

Figure 6


Lifting Shingle
Angle Drilling
Thumb Tacks
Channel in Fire Stop

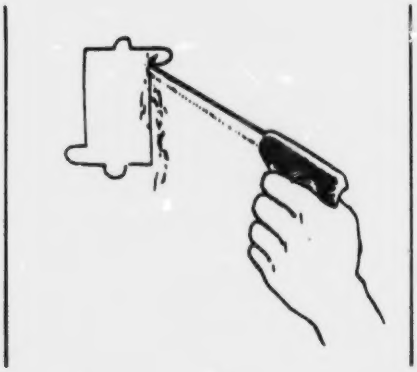
Information Sheet

5. **Wall or ceiling composition** (Figures 7-14)

   a. Plasterboard

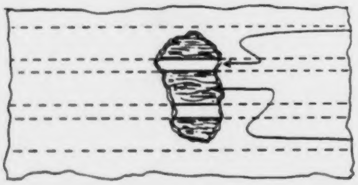
   Note: This is commonly called Sheetrock® and is used on the majority of interior walls in new structures.

   Figure 7



   b. Lath and plaster

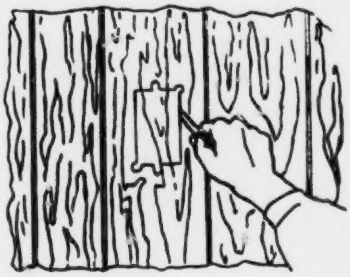
   Figure 8



Information Sheet

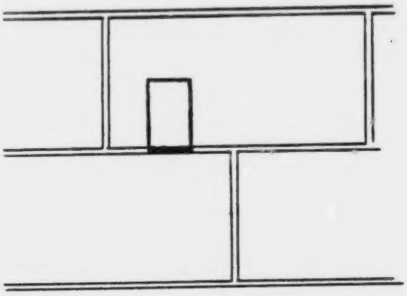
c. Paneling

Figure 9



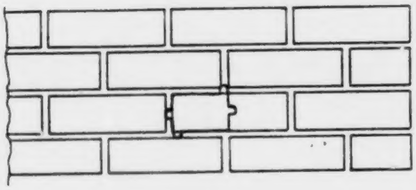
d. Concrete block

Figure 10



e. Brick

Figure 11



Information Sheet

6. **Optional calculation for additional loads to existing installations**

   Note: For the purpose of allowing additional loads to be connected to existing feeders and services, it shall be permitted to use the actual maximum KVA demand figures to determine the existing load on a service or feeder when all the following conditions are met. Refer to *NEC* Article 220-35(1)(2)(3).

   a. The maximum demand data is available in kVA for a minimum of a 1 year period.

   b. The existing demand at 125 percent plus the new load does not exceed the ampacity of the feeder or rating of the service.

   c. The feeder or service has overcurrent protection in accordance with sections 240-3, and the service has overload protection in accordance with 230-90.

      Note: Article 230-90 requires overload protection in each ungrounded conductor. Article 240-3 requires that conductors other than flexible cords and fixture wires be protected against overcurrent in accordance with their ampacities as specified in Section 310-15.

7. **Exceptions to the *NEC* requirements for support of flexible metal conduit**

   Note: Refer to *NEC* Article 350-4.

   a. Where flexible metal conduit is fished

   b. Lengths not exceeding 3 feet

   c. Lengths not exceeding 6 feet from a fixture terminal connection for tap connections to lighting fixtures as required in 410-67(c)

8. **Steps for determining the number of conductors allowed in a conduit, based on cross sectional area**

   a. Determine size of existing conduit.

   b. Determine number and size of existing conductors.

   c. Find area of conduit or tubing, using Table 4, Chapter 9 of the *NEC*.

   d. Compute total area occupied by existing conductors, based on Table 5, Chapter 9 of the *NEC*.

Information Sheet

e. Determine number of conductors that may be added.

Example: An existing 1-inch conduit contains three #8 THHN conductors. Four #12 THW conductors need to be added to feed a new circuit.

1-inch conduit with over two conductors not lead covered has an area of .34 square inches (Table 4, Chapter 9)

#8 THHN has an area of .0373 sq. in. (Table 5, Chapter 9)

$$\begin{array}{r} .0373 \text{ sq. in.} \\ \underline{\times \quad 3} \\ .1119 \text{ sq. in.} \end{array}$$

#12 THW has an area of .0172 sq. in. (Table 5, Chapter 9)

$$\begin{array}{r} .0172 \text{ sq. in.} \\ \underline{\times \quad 4} \\ .0688 \text{ sq. in.} \end{array}$$

Total area required for conductors is:

$$\begin{array}{r} .1413 \\ \underline{+.0688} \\ .2101 \text{ sq. in.} \end{array}$$

.2101 is less than .34; therefore, the four #12 THW conductors may be added.

Existing Structures
Unit 16

Assignment Sheet 1—Determine the Number of Conductors Allowed to be Added to an Existing Conduit

Name ______________________________ Overall Rating __________

Evaluation criteria	Rating
Assignment answers complete	______
All three answers are correct per Answers to Assignment Sheet 1	______

Directions: Using the steps listed in Objective 8 of the Information Sheet and the *NEC*, determine whether additional conductors may be added to a conduit or whether a new conduit is necessary. Show your calculations.

A. An existing ¾-inch conduit contains three #10 THW conductors; you need to add three more #10 THW conductors. Can you do so?

B. A ½-inch conduit contains three #12 THHN conductors. Will four more #12 THHN conductors be allowed?

Assignment Sheet 1

C. A 1½-inch conduit contains three I/O THW conductors. Will three #6 THHN conductors be allowed?

Existing Structures
Unit 16

Job Sheet 1—Install a Box with Dry-Wall Grips in a Plasterboard Wall

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Gathered and used appropriate equipment and materials	______
Performed procedure safely	______
Performed all steps in procedure	______
Cleaned work area	______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and rate you performance using the above criteria.

A. Equipment and materials

Plasterboard wall
Box with plaster ears and dry-wall grips

Note: Several forms of attaching devices are made for securing boxes in dry-wall plasterboard.

Pouch tools
½-inch drill bit
Brace or drill motor and cord
Pencil
Keyhole saw
Safety glasses
Drop cloth
Duplex receptacle

Job Sheet 1

B. Procedure

Note: Before starting, be sure that you will be able to get a cable to where you will cut in the box.

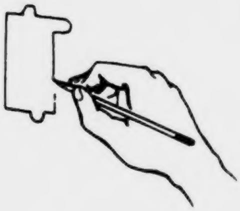
☐ 1. Gather equipment and materials, and put on safety glasses.

☐ 2. Mark box height on wall.

☐ 3. Pencil around box. (Figure 1)

Note: Tap along the wall, listening for hollow spaces, or use a stud finder to make sure that a stud will not be in the cut-out for the box.

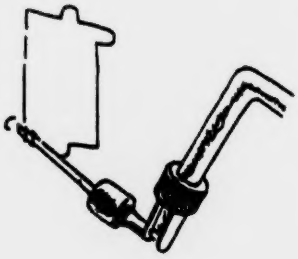
Figure 1



☐ 4. Place drop cloth below work area.

☐ 5. Drill holes in two of the corners. (Figure 2)

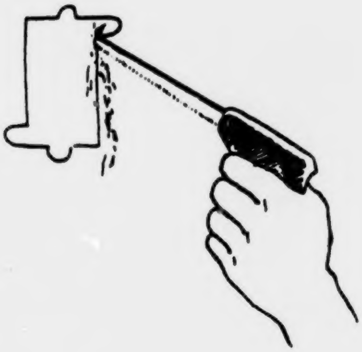
Figure 2



Job Sheet 1

☐ 6. Saw along drawn lines. (Figure 3)

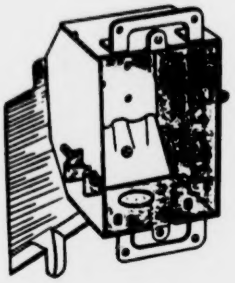
Figure 3



☐ 7. Fit box into opening. (Figure 4)

Note: You may need to do some trimming. The plasterboard will chalk white places on the box in areas where trimming is needed.

Figure 4



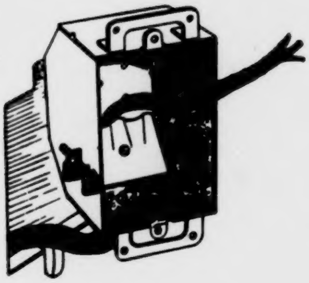
☐ 8. Remove box.

☐ 9. Insert conductors.

Job Sheet 1

☐ 10. Replace box in opening. (Figure 5)

Figure 5



☐ 11. Secure box.

Note: Tighten screw until box is secure.

☐ 12. Pick up drop cloth.

☐ 13. Clean work area, and return equipment and materials to proper storage.

Evaluator's comments: ____

____

____

Existing Structures
Unit 16

Job Sheet 2—Secure a Box with Dry-Wall Supports (Boxtins)

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation criteria	**Rating**
Gathered and used appropriate equipment and materials	______
Performed procedure safely	______
Performed all steps in procedure	______
Cleaned work area	______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and rate you performance using the above criteria.

A. Equipment and materials

Note: This job sheet deals only with the securing of boxes after the cable has been run and the opening cut.

Dry-wall box with ears
Dry-wall box supports (boxtins)
Opening in dry wall
Lineman's pliers

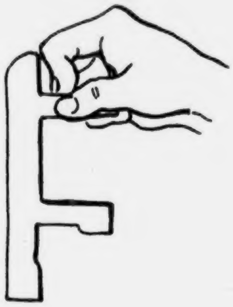
Job Sheet 2

B. Procedure

☐ 1. Place box in opening.

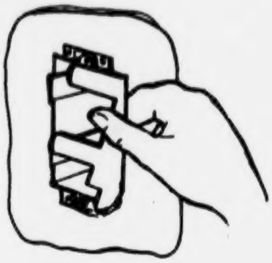
☐ 2. Grip box supports (boxtins) in one hand. (Figure 1)

Figure 1



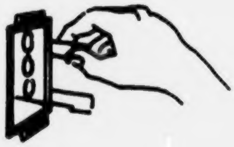
☐ 3. Insert bottom of support beside box. (Figure 2)

Figure 2



☐ 4. Push in top of support. (Figure 3)

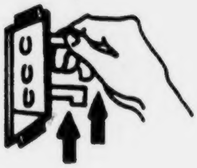
Figure 3



Job Sheet 2

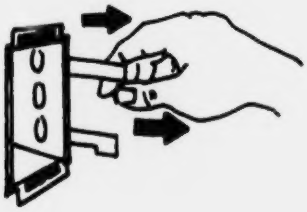
☐ 5. Raise support about ½ inch. (Figure 4)

Figure 4



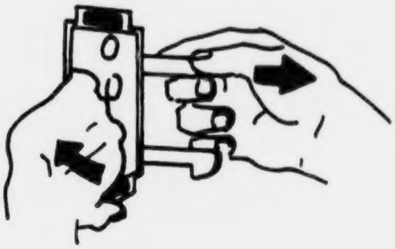
☐ 6. Apply outward pressure on support. (Figure 5)

Figure 5



☐ 7. Put inward pressure on box with other hand. (Figure 6)

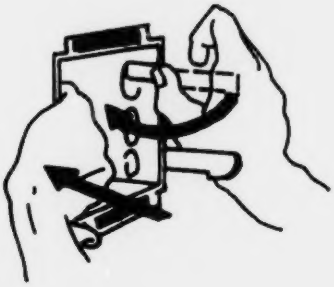
Figure 6



Job Sheet 2

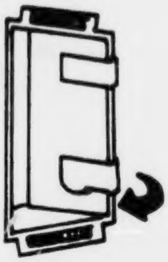
☐ 8. Bend tang over to secure box. (Figure 7)

Figure 7



☐ 9. Bend other tang. (Figure 8)

Figure 8

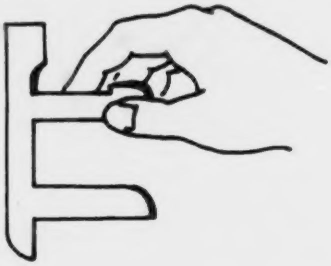


Job Sheet 2

☐ 10. Grasp other support. (Figure 9)

Note: This support may be inserted with the long spine in the opposite direction of the first.

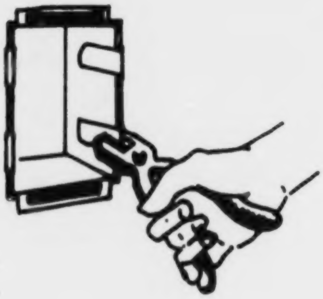
Figure 9



☐ 11. Secure in wall, using Steps 3 through 9.

☐ 12. Pinch tangs with lineman's pliers. (Figure 10)

Figure 10



Note: Have instructor evaluate work.

☐ 13. Clean work area, and return equipment and materials to proper storage.

Evaluator's comments: ______________________________

____

____

Existing Structures
Unit 16

Job Sheet 3—Install a Box in a Lath and Plaster Wall

Name ____________________ Attempt Number ________

Date ____________________ Overall Rating ________

Evaluation criteria	**Rating**
Gathered and used appropriate equipment and materials	______
Performed procedure safely	______
Performed all steps in procedure	______
Cleaned work area	______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and rate you performance using the above criteria.

A. Equipment and materials

Lath and plaster wall
Box with plaster ears
Two #6 or #4 × ¾-inch metal tapping or wood screws
Pouch tools
Keyhole saw
Pencil
Safety glasses
Drop cloth

B. Procedure

Note: Before starting, be sure that you will be able to get a cable to where you will cut in the box.

☐ 1. Gather equipment and materials and put on safety glasses.

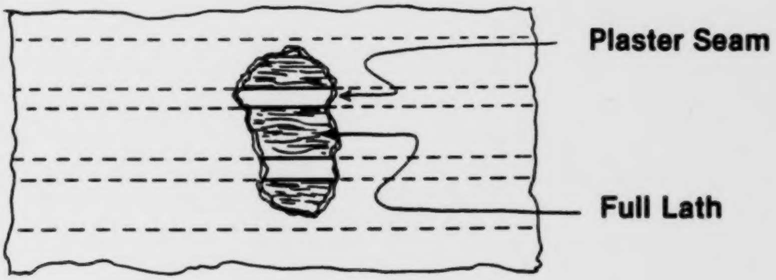
☐ 2. Mark box height on wall.

☐ 3. Place drop cloth below work area.

☐ 4. Punch a hole near your mark with a screwdriver.

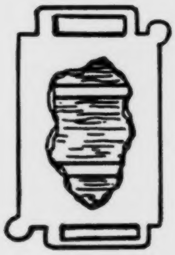
Job Sheet 3

☐ 5. Locate full lath. (Figure 1)


Plaster Seam
Full Lath

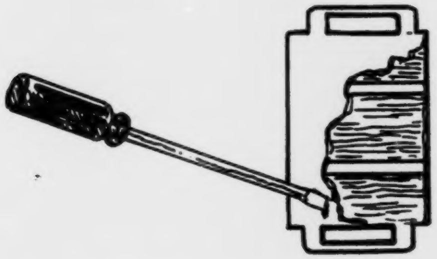
☐ 6. Pencil around box, using full lath as center point. (Figure 2)

Figure 2



☐ 7. Break out plaster along penciled line with screwdriver. (Figure 3)

Figure 3

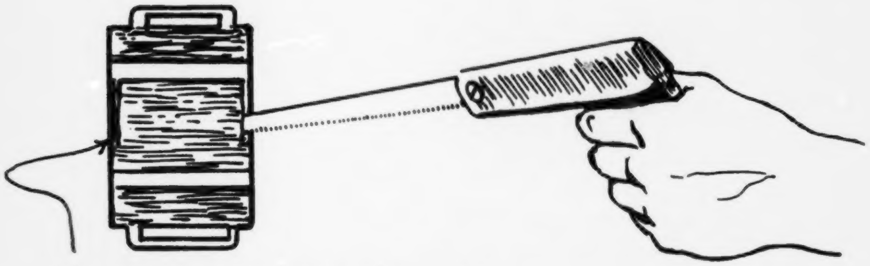


Job Sheet 3

☐ 8. Cut out center lath completely. (Figure 4)

Note: It will be easier if you do not cut completely through one side before starting on the other. Leaving a small connecting point stops a lot of vibration. Sometimes it may be necessary to wedge the lath with a screwdriver to eliminate vibration.

Figure 4



(Do not cut completely through)

☐ 9. Cut enough of top and bottom lath to accommodate box.

☐ 10. Install cable in box.

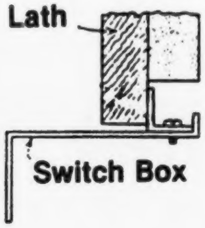
☐ 11. Place box in opening.

☐ 12. Secure with screws.

☐ 13. Reset plaster ears if plaster breaks from behind ears.

Note: If the plaster is not solid enough to provide firm support, clean it out from behind ears. See Figure 5.

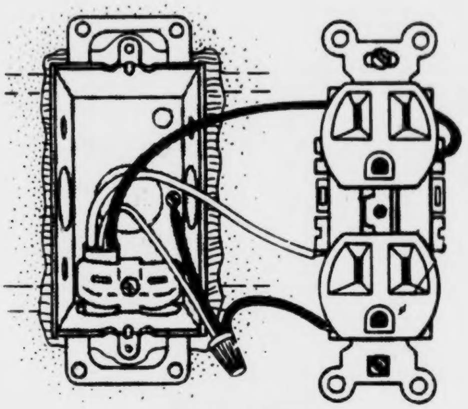
Figure 5



Job Sheet 3

☐ 14. Secure with screws. (Figure 6)

Figure 6



Front View

☐ 15. Install receptacle.

Note: Have instructor check your work.

☐ 16. Pick up drop cloth.

☐ 17. Clean work area, and return equipment and materials to proper storage.

Evaluator's comments: ______________________________

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Existing Structures
Unit 16

Job Sheet 4—Install a Box in a Paneled Wall

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Gathered and used appropriate equipment and materials	______
Performed procedure safely	______
Performed all steps in procedure	______
Cleaned work area	______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and rate you performance using the above criteria.

A. Equipment and materials

Paneled wall
Pouch tools
½-inch drill bit
Brace or drill motor and cord
Keyhole saw
Pencil
Drop cloth
Switch box with ears

Masking tape
Safety glasses
Portable GFCI
Four #6 × ¾-inch metal-tapping or woodscrews

Note: If plasterboard is behind the paneling, you can use one of the forms of dry-wall grips.

B. Procedure

Note: Before starting be sure that you will be able to get a cable to where you will cut in the box.

☐ 1. Gather equipment and materials and put on safety glasses.

☐ 2. Mark box height on wall.

☐ 3. Pencil around box.

Note: Notice nail locations, use a stud finder, or tap for hollow sounds to make sure that you are in a hollow space.

Job Sheet 4

☐ 4. Put masking tape over lines and re-mark if not visible.

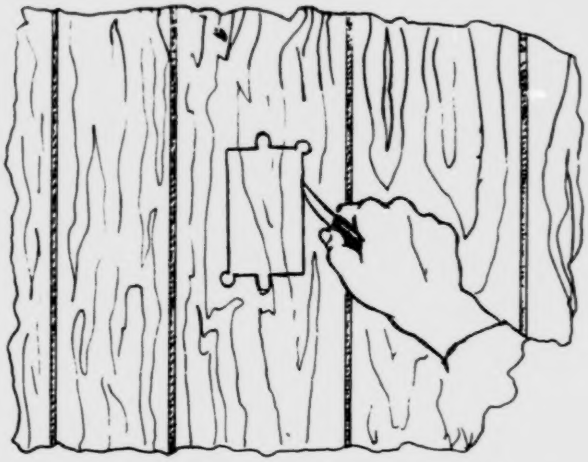
Note: This will prevent wood from splintering while drilling and sawing.

☐ 5. Place drop cloth below work area.

☐ 6. Cut along penciled lines with knife. (Figure 1)

Note: If you do not cut through the top layer of the paneling, it will splinter when you start sawing.

Figure 1



☐ 7. Drill holes in two corners of penciled in box.

Note: Be sure and plug cord in GFCI if a drill motor is used.

☐ 8. Saw out opening.

Note: Saw inside of your knife cut to avoid splintering the paneling.

☐ 9. Fit box into opening.

Note: If you have to trim the opening, use your knife instead of the saw to avoid splintering.

☐ 10. Remove box.

☐ 11. Install cable.

Job Sheet 4

☐ 12. Reinstall box in opening.
☐ 13. Secure box.
☐ 14. Remove masking tape.

Note: Have instructor check your work.

☐ 15. Pick up drop cloth.
☐ 16. Clean work area, and return equipment and materials to proper storage.

Evaluator's comments: ______________________________

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Existing Structures
Unit 16

Job Sheet 5—Install a Box in a Concrete Block Wall

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation criteria	**Rating**
Gathered and used appropriate equipment and materials	______
Performed procedure safely	______
Performed all steps in procedure	______
Cleaned work area	______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and rate you performance using the above criteria.

A. Equipment and materials

Pouch tools
Concrete block wall
Concrete chisel
Switch box with ears
Pencil
Mortar, commercial pre-mix or sand and cement mixture you blend yourself
Wood scraps
Safety glasses

B. Procedure

Note: Before starting, be sure that you will be able to get a cable to where you will cut in the box.

☐ 1. Gather equipment and materials, and put on safety glasses.

☐ 2. Mark approximate box height.

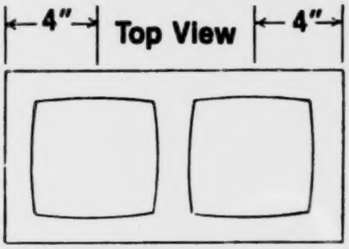
Note: Make your mark in a mortar joint at the top or bottom edge of a block.

Job Sheet 5

☐ 3. Pencil around box.

Note: Make sure that your box will be centered in a hollow space in the concrete block. There should be a hollow space on an 8″ × 8″ × 16″ block 4 inches from either end.

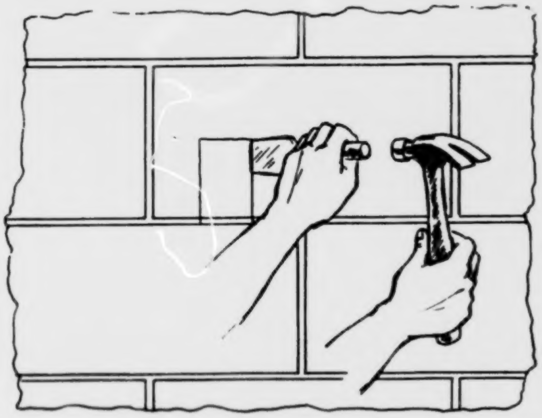
Figure 1



☐ 4. Tap chisel along pencil lines with hammer. (Figure 1)

Note: This should be done until a groove approximately 1/16-inch deep replaces your penciled outline.

Figure 2

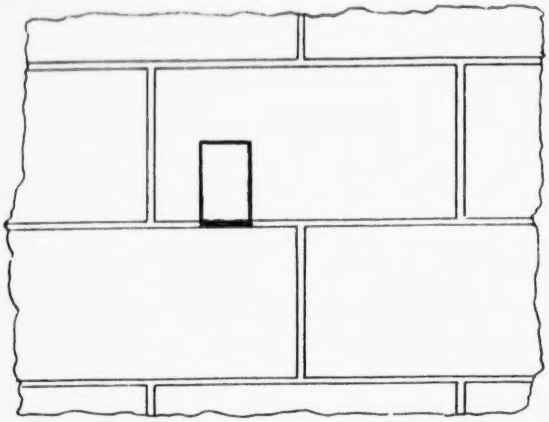


Job Sheet 5

☐ 5. Knock mortar out along box outline. (Figure 2)

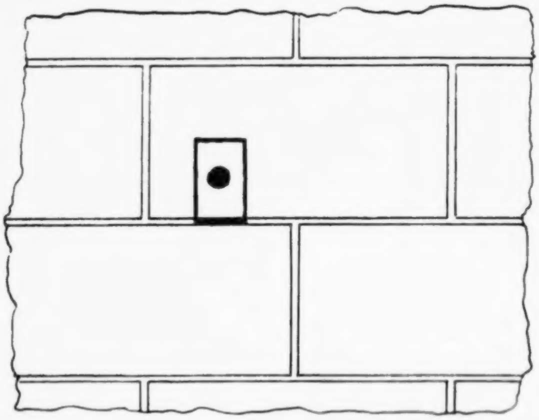
Note: If mortar is difficult to remove, you can drill it out. Be sure to use portable GFCI.

Figure 3



☐ 6. Tap center of box outline with hammer to form a hole. (Figure 4)

Figure 4



☐ 7. Gently tap from center hole toward grooved box outline.

Note: The block should crack off at the groove. Do not hurry. Slowly work around the groove until the opening is formed.

Job Sheet 5

☐ 8. Fit box into opening.

Note: The hole may have to be dressed with the chisel until the box fits.

☐ 9. Remove box.

☐ 10. Install cable in box.

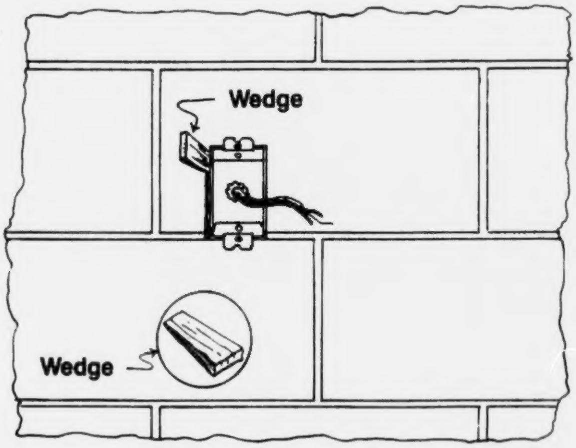
Note: You may have to enter the back of the box; in this event you will need a ⅜-inch cable clamp.

☐ 11. Reinstall box in opening.

☐ 12. Secure box with narrow wood wedges. (Figure 4)

Note: The wedges can be made by chipping at the end of a 2-by-4 with your hammer claws. Put one wedge at the top and one at the bottom in opposite corners.

Figure 5



☐ 13. Flush off wood securing wedges.

Note: Even if the box seems secure, you must use mortar or construction adhesive to finish the process.

☐ 14. Mix a small amount of mortar.

☐ 15. Force mortar between box and opening in block.

Job Sheet 5

☐ 16. Smooth out excess mortar.

Note: Have instructor check your work.

☐ 17. Clean work area, and return equipment and materials to proper storage.

Evaluator's comments: ______________________________

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Existing Structures
Unit 16

Job Sheet 6—Install a Box in a Brick Wall

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation criteria	Rating
Gathered and used appropriate equipment and materials	______
Performed procedure safely	______
Performed all steps in procedure	______
Cleaned work area	______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and rate you performance using the above criteria.

A. Equipment and materials

Brick wall
Pouch tools
Switch box with ears
2 plastic anchors with appropriate bit and screws
Concrete chisel
Pencil
Mortar
¾-inch cable clamp
Portable GFCI
Safety glasses
Drill motor and cord
¼-inch masonry bit

Note: The bit could be larger; however, a large bit will usually take more time to make the necessary penetrations.

B. Procedure

Note: Before starting, be sure that you will be able to get a cable to where you will cut in the box.

☐ 1. Gather equipment and materials, and put on safety glasses.

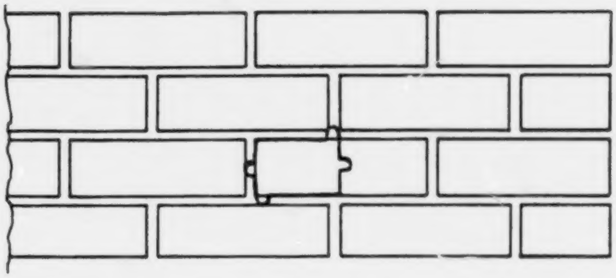
☐ 2. Mark box height on wall.

Job Sheet 6

☐ 3. Pencil around box. (Figure 1)

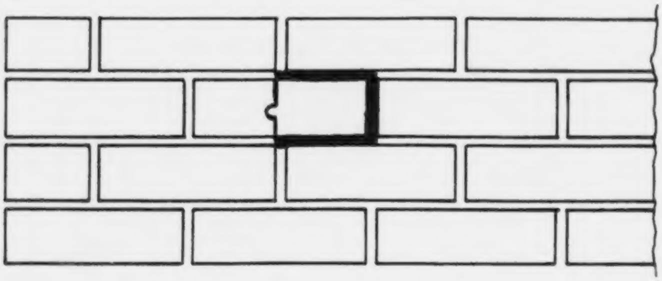
Note: Place the box horizontally so that only one cut is needed in a brick. However, if existing outlets are installed vertically, then this box should also be installed vertically.

Figure 1



☐ 4. Chisel the mortar from around your penciled-in box. (Figure 2)

Figure 2

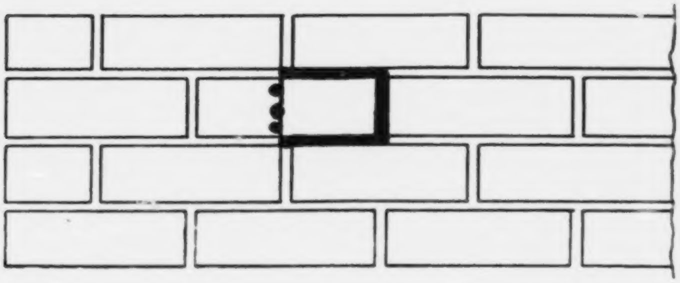


Job Sheet 6

☐ 5. Drill three or four holes along box outline in brick. (Figure 3)

Note: Be sure to use GFCI with your power tools.

Figure 3



☐ 6. Chisel a groove between the drill holes.

Note: The brick may break while you are grooving it.

☐ 7. Tap on the free end of the brick until it breaks.

Note: Do not push the brick bat back into the wall. Remove it from the wall when it breaks.

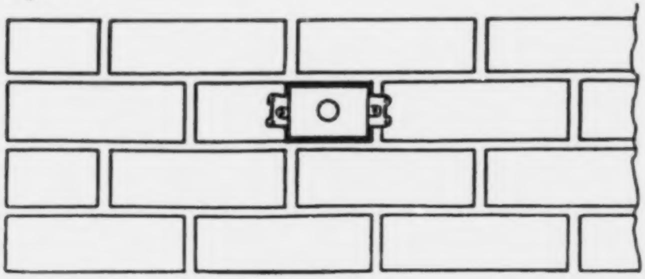
☐ 8. Fit box in opening.

Note: You may have to dress the hole with the concrete chisel.

☐ 9. Mark holes for anchors in plaster ears. (Figure 4)

Note: One in each ear is sufficient.

Figure 4



Job Sheet 6

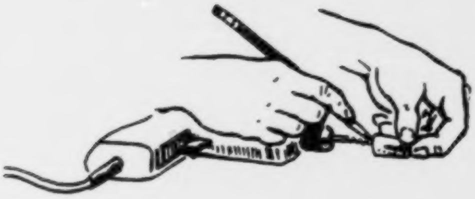
☐ 10. Remove box.

11. Install anchors.

    ☐ a. Measure anchor on drill bit. (Figure 5)

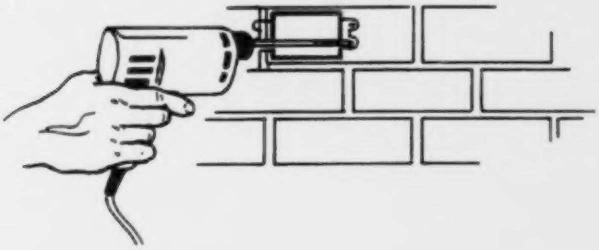
    Note: This technique tells you when to stop so that your anchor will bottom out.

    Figure 5



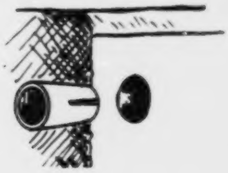
    ☐ b. Drill hole to marked depth. (Figure 6)

    Figure 6



    ☐ c. Insert small end of anchor in hole. (Figure 7)

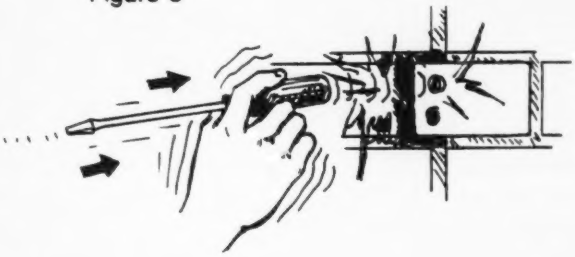
    Figure 7



Job Sheet 6

☐ d. Tap with screwdriver butt to seat. (Figure 8)

Figure 8



☐ 12. Replace cable in box.

☐ 13. Secure cable clamp.

☐ 14. Insert box in opening.

☐ 15. Install screws in anchor.

☐ 16. Secure box.

☐ 17. Mix mortar.

☐ 18. Fill joints around box.

☐ 19. Smooth joints with finger.

Note: Have instructor check your work.

☐ 20. Clean work area, and return equipment and materials to proper storage.

Evaluator's comments: ______________________________

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Existing Structures
Unit 16

Job Sheet 7—Install a Box in a Ceiling with an Accessible Attic

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Gathered and used appropriate equipment and materials	______
Performed procedure safely	______
Performed all steps in procedure	______
Cleaned work area	______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and rate you performance using the above criteria.

A. Equipment and materials

Pouch tools
Keyhole saw
Octagon box
Bar hanger
Pencil
Drop cloth
Step ladder
Safety glasses
½-inch drill bit
Brace or drill motor and cord
2 single or plasterboard nails
Trouble light and bulb
Portable GFCI

B. Procedure

Note: Before starting, be sure that you will be able to get a cable to where you will cut in the box.

☐ 1. Gather equipment and materials, and put on safety glasses.

☐ 2. Set up ladder.

☐ 3. Place drop cloth under work area.

☐ 4. Mark box location on ceiling.

Job Sheet 7

☐ 5. Pencil around box.

Note: Be sure that there is not a ceiling joist above where you plan on cutting in the box.

☐ 6. Drill a hole in corner of box outline.

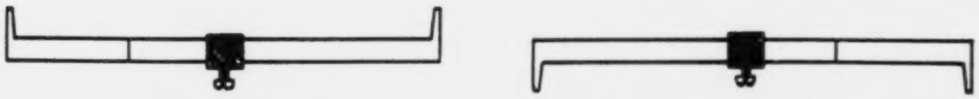
☐ 7. Saw out box opening.

Note: If the ceiling is lath, chip the plaster off the inside of your outline before you saw the lath.

☐ 8. Attach bar to box. (Figure 1)

Note: Reverse the bar so that the nail slots are upward for easy nailing. Installation must comply with *NEC* Article 370-13.

Figure 1



Reversed bar **Standard**

☐ 9. Move ladder to attic access hole.

☐ 10. Plug in drop light.

☐ 11. Go into attic with pouch tools, nails, box, and trouble light.

☐ 12. Walk to the box opening, taking care to walk only on ceiling joists.

> **Caution: Do not step between joists, or you may step through the ceiling below.**

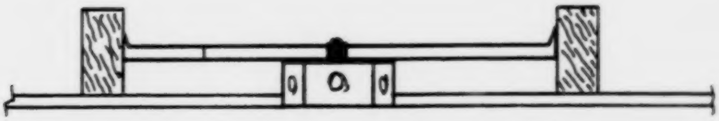
☐ 13. Position box in hole.

Job Sheet 7

☐ 14. Nail bar hanger between joists. (Figure 2)

Note: Be sure that box is flush with ceiling.

Figure 2



☐ 15. Insert cable in box.

☐ 16. Gather tools and light.

☐ 17. Descend from attic.

☐ 18. Reposition ladder.

☐ 19. Tighten cable clamp and box support screw.

Note: Have instructor check your work.

☐ 20. Pick up drop cloth.

☐ 21. Clean work area, and return equipment and materials to proper storage.

Evaluator's comments: ____

____

____

Existing Structures
Unit 16

Job Sheet 8—Install Cable Between an Existing Box and a Newly Installed Box Horizontally Along a Wall in a Channel Behind Baseboard

Name ____________________ Attempt Number __________

Date ____________________ Overall Rating __________

Evaluation criteria	**Rating**
Gathered and used appropriate equipment and materials	______
Performed procedure safely	______
Performed all steps in procedure	______
Cleaned work area	______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and rate you performance using the above criteria.

A. Equipment and materials

- Pouch tools
- Keyhole saw
- 12-2G cable
- Suitable box with some type of drywall fasteners
- Drop cloth
- Whisk broom
- Touch up materials, including paint and brush if needed
- Safety glasses
- Chisel
- Flat bar

B. Procedure

☐ 1. Put on safety glasses.

☐ 2. Gather equipment and materials.

☐ 3. Cut in new box.

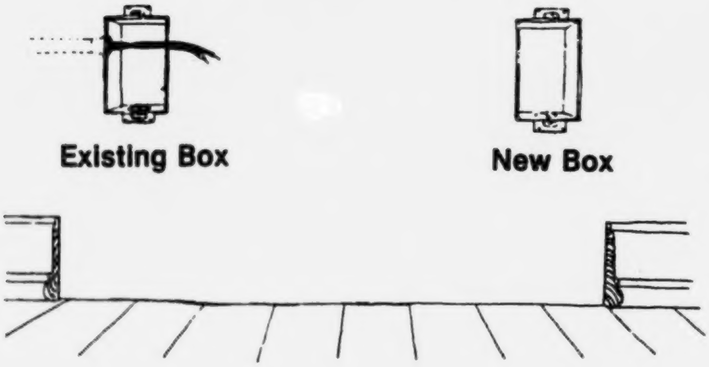
Note: Be sure to consider wall covering materials before making your opening.

Job Sheet 8

4. Remove baseboard between boxes. (Figure 1)

   Note: The illustrations show the boxes on the same wall. The baseboard will have to be removed from two walls if you install the new box on another wall.

Figure 1



☐ a. Pry out baseboard with flat bar, starting at one end and working evenly along baseboard.

☐ b. Cut nails flush to baseboard.

☐ c. Lay baseboard aside until needed.

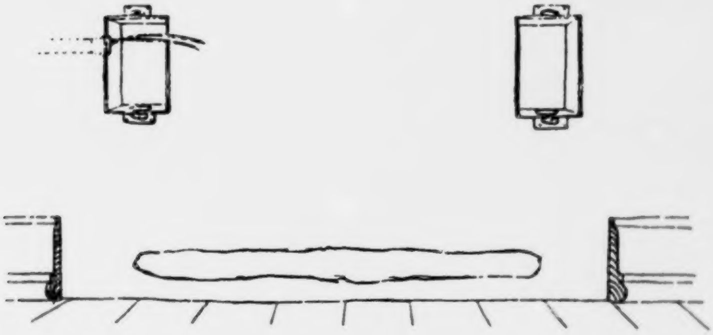
☐ 5. Place drop cloth along floor line.

Job Sheet 8

☐ 6. Form channel with hammer and chisel. (Figure 2)

Note: Be sure that your channel will be covered by the baseboard. Most older houses have a sufficiently tall baseboard.

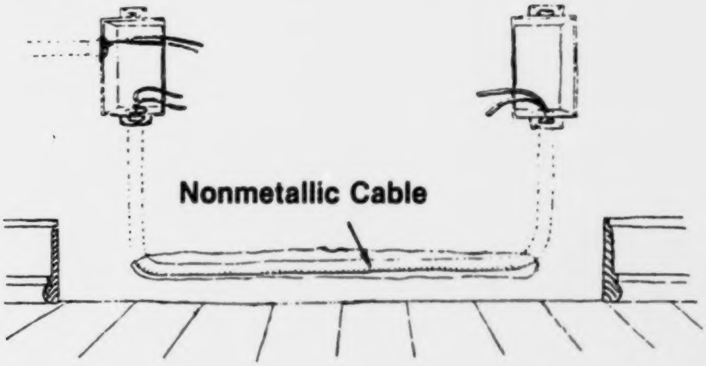
Figure 2



☐ 7. Install cable. (Figure 3)

Note: You may have to bore a hole through a piece of lath or through the top edge of a bottom plate.

Figure 3

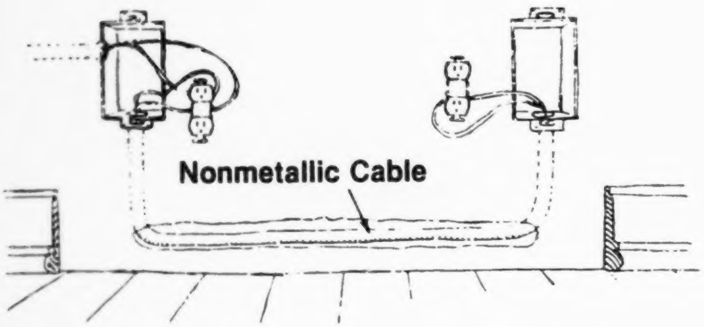


Job Sheet 8

☐ 8. Install devices. (Figure 4)

Note: Refer to *NEC* Article 300-13 for requirements of conductor continuity.

Figure 4

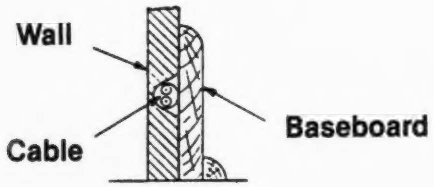

Nonmetallic Cable

9. Replace baseboard.

☐ a. Check cable fit. (Figure 5)

Note: The baseboard should fit back flat against the wall.

Figure 5


Wall
Cable
Baseboard

☐ b. Renail baseboard.

Caution: Take care not to puncture the cable with the nails.

Job Sheet 8

☐ 10. Touch-up baseboard.

Note: The homeowner may have some of the original paint.

☐ 11. Pick up drop cloth.

Note: Have instructor check your work.

☐ 12. Clean work area, and return equipment and materials to proper storage.

Evaluator's comments: ______________________________

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Existing Structures
Unit 16

Job Sheet 9—Install Cable Between an Existing Box and a Newly Installed Box, Using an Underfloor Crawl Space

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Gathered and used appropriate equipment and materials	______
Performed procedure safely	______
Performed all steps in procedure	______
Cleaned work area	______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and rate you performance using the above criteria.

A. Equipment and materials

Pouch tools
Drop light and cord
Drill motor
Ship auger bit
Suitable box with dry-wall fasteners
12-2G cable
Staples
Drop cloth
Fish wire
String
Tape
Portable GFCI
Volt ohmmeter
Safety glasses

B. Procedure

Note: Turn off and check circuit before starting. Be sure that there is enough space under the floor to work before this method is used.

☐ 1. Put on safety glasses.

☐ 2. Gather equipment and materials

☐ 3. Cut in new box.

☐ 4. Remove existing device.

Job Sheet 9

☐ 5. Locate crawl space access hole.

☐ 6. Connect GFCI to outlet and cord to GFCI.

☐ 7. Locate place to drill.

Note: A nail can be driven down through the floor, or measurements can be taken from above and transferred to below.

☐ 8. Drill holes. (Figures 1 and 2)

Note: In some instances you may have to remove the baseboard and drill down on outside walls. It is usually better, however, to drill from below.

Figure 1

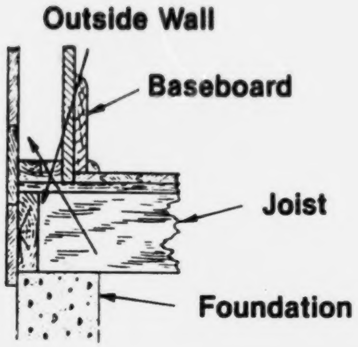
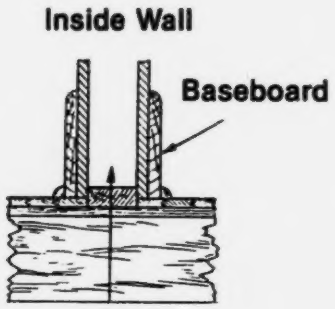

Outside Wall
Baseboard
Joist
Foundation

Figure 2


Inside Wall
Baseboard

9. Make opening at existing box for cable.

   ☐ a. Remove a knockout from box.

   Note: If a knockout cannot be removed, remove the box.

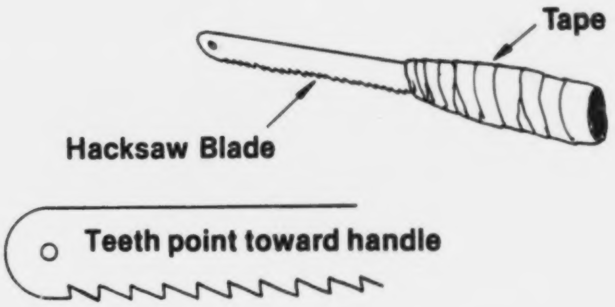
Job Sheet 9

☐ b. Remove box if necessary.

  ☐ (1) Insert saw between box and stud.

  Note: A saw can be constructed with an old or broken hacksaw blade. See Figure 3.

Figure 3


Tape
Hacksaw Blade
Teeth point toward handle

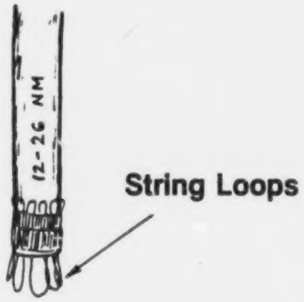
  ☐ (2) Cut nails.

  ☐ (3) Move box out of way.

10. Fish wire through drilled hole.

☐ a. Tape string in loops to cable. (Figure 4)

Figure 4


12-2G NM
String Loops

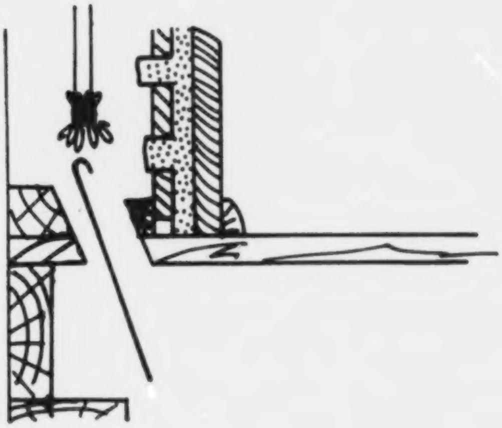
Job Sheet 9

☐ b. Push cable in opening.

Note: Insulation in walls may make it more difficult to fish the wires.

☐ c. Push fish wire with loop up from bottom and wiggle to hook loops. (Figure 5)

Figure 5



☐ d. Pull cable through hole while being fed from above.

Note: This effort needs to be coordinated among the people working. Signals such as two quick jerks for more cable to be fed should be established.

☐ e. Pull cable over to other hole.

☐ f. Push through hole and fish from above.

☐ 11. Staple cable as code requires.

☐ 12. Install new box.

Note: Install original existing box if it was removed.

☐ 13. Install devices.

☐ 14. Activate circuit and test it.

Job Sheet 9

Note: Have instructor check your work.

☐ 15. Reseal crawl space access hole.

☐ 16. Clean work area, and return equipment and materials to proper storage.

Evaluator's comments: ______________________________

____

____

Existing Structures
Unit 16

Job Sheet 10—Install Cable Between an Existing Box and a Newly Installed Box Using an Attic Space

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Gathered and used appropriate equipment and materials	______
Performed procedure safely	______
Performed all steps in procedure	______
Cleaned work area	______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and rate you performance using the above criteria.

A. Equipment and materials

Pouch tools
Drop light and cord
Drill motor
Ship auger bit
Suitable box with dry-wall fasteners
12-2G cable
Staples
Drop cloth
Crop chain
Steel fish tape
Volt ohmmeter
Ladder (tall enough to allow easy entry into attic)
Tape
Safety glasses
Dust mask
Portable GFCI

B. Procedure

Note: Be sure to turn off and check circuit before starting.

☐ 1. Put on safety glasses.

☐ 2. Gather equipment and materials.

☐ 3. Put down drop cloth.

☐ 4. Remove existing device.

Job Sheet 10

☐ 5. Plug in GFCI and drop light.

☐ 6. Set up ladder at access hole.

7. Put the following materials up in the attic:
   - ☐ a. Pouch tools
   - ☐ b. Drop chain
   - ☐ c. Drop light
   - ☐ d. Drill motor and bit
   - ☐ e. Distance measured for drilling written on paper

☐ 8. Put on dust mask.

☐ 9. Enter attic carefully.

Note: When traveling across the attic be sure and walk on ceiling joists. You may have to brush insulation aside as you walk to locate them.

☐ 10. Locate spot to drill.

☐ 11. Drill hole.

Note: On inside walls, drilling should be no problem. On outside walls, the pitch of the roof may affect how you get through or around the top plate.

☐ 12. Drop one end of chain in hole.

Note: You can stick a screwdriver through one end of the chain to be sure that it does not slip from your hand and fall through the hole. Insulated exterior walls may require the use of a solid wire or fish tape.

☐ 13. Shake chain until located below through opening.

☐ 14. Cut in new box.

Note: Measurements should be taken carefully so that the holes bored from the attic are in the right stud space.

☐ 15. Pull end of chain through hole.

Job Sheet 10

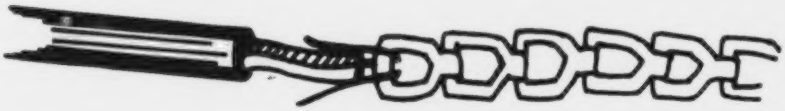
16. Fasten chain to cable.

☐ a. Strip about 6 inches of outer cable sheath.

☐ b. Strip about 2 inches of insulation from conductors.

☐ c. Insert conductors in chain loops and bend over. (Figure 1)

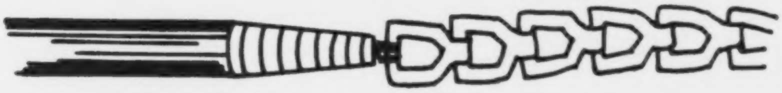
Figure 1



☐ d. Tape the connecting joint back over the cable. (Figure 2)

Note: A smooth joint allows the cable to pass through the drilled hole without hanging up.

Figure 2



☐ 17. Pull cable up into attic.

Note: A couple of tugs on the chain can signal the technician in the attic to start pulling up. Cable should be pulled in 2- or 3-foot lifts to allow feed person to straighten cable as it is fed.

☐ 18. Pull enough cable to go over to next hole and down to existing box.

Note: Pull plenty, because you can refeed excess back down to new box before it is cut.

☐ 19. Drill hole above existing outlet.

Note: Sometimes a hole already exists where another cable goes down. Use this space if it is large enough.

Job Sheet 10

☐ 20. Drop chain into hole.

☐ 21. Fish chain out of existing box.

Note: If a knockout will not allow you to fish chain, cut nails and remove box.

☐ 22. Pull out enough cable for installation.

☐ 23. Pull excess back through new hole.

☐ 24. Staple cable in attic.

☐ 25. Remove equipment and materials from attic.

Note: The technician below should be waiting to receive materials as they are handed down.

☐ 26. Replace attic access cover.

☐ 27. Install devices.

☐ 28. Activate circuit.

☐ 29. Test devices.

Note: Have your instructor check your work.

☐ 30. Clean work area, and return equipment and materials to proper storage.

Evaluator's comments: ______________________________

____

____

Related Math and Measuring
Unit 17

Objective Sheet

Unit Objective

After completing this unit, the student should be able to solve basic math problems and read English and metric rules. The student should demonstrate these competencies by completing the assignment sheets and scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms associated with math and measuring to their correct definitions.
2. Match symbols used in math problems with their names.
3. Label the place values of a whole number.
4. Add whole numbers. (Assignment Sheet 1)
5. Subtract whole numbers. (Assignment Sheet 2)
6. Multiply whole numbers. (Assignment Sheet 3)
7. Divide whole numbers. (Assignment Sheet 4)
8. Distinguish among types of fractions.
9. Reduce fractions to lowest terms. (Assignment Sheet 5)
10. Convert fractions and mixed numbers. (Assignment Sheet 6)
11. Add fractions. (Assignment Sheet 7)
12. Subtract fractions. (Assignment Sheet 8)
13. Multiply fractions. (Assignment Sheet 9)
14. Label the place values of a decimal number.
15. Add decimal numbers. (Assignment Sheet 10)
16. Subtract decimal numbers. (Assignment Sheet 11)

Objective Sheet

17. Multiply decimal numbers. (Assignment Sheet 12)

18. Divide decimal numbers. (Assignment Sheet 13)

19. Convert fractions and percentages. (Assignment Sheet 14)

20. Solve percentage problems. (Assignment Sheet 15)

21. Match terms used in geometry with their definitions.

22. Match types of geometric figures with their descriptions.

23. Match units of measure with their equivalents.

24. Calculate area of geometric figures. (Assignment Sheet 16)

25. Match metric prefixes with their values.

26. Read English and metric rules.

Related Math and Measuring
Unit 17

Suggested Activities

Instructional Plan

Preparation

1. Read the unit carefully and plan for instruction. Study the specific objectives to determine the order in which you will present them.

2. Review Teaching Suggestions section that follows. Plan for classroom activities.

3. Plan your presentation to take advantage of student learning styles and to accommodate special needs students.

4. Make transparencies from the transparency masters included with this unit. These appear in the teacher edition only and are designed to be used with Objective 26.

   TM 1 and 2—Graduations on a Rule
   TM 3—Reading Fourths on a Rule
   TM 4—Reading Eighths on a Rule
   TM 5—Reading Sixteenths on a Rule
   TM 6—Reading Decimal Inches
   TM 7—Reading Measurements on a Metric Rule

5. Obtain films, videotapes, and other resources to supplement instruction of this unit. See ordering information in the Suggested Supplemental Resources section that follows.

6. Develop teaching plan. Adjust for different learning styles.

7. Make copies of Unit Evaluation Form.

Delivery and Application

8. Provide students with unit of instruction.

9. Discuss unit and specific objectives.

10. Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.

11. Discuss the assignment sheets and schedule due date. Review criteria for evaluation of these activities.

Suggested Activities

Evaluation

12. Discuss the use of the Unit Evaluation Form with students. Discuss the rating scale that will be used for student evaluation.

13. Administer the pretest to determine individual study requirements. Modify materials in unit or create supplementary materials for individual students as required.

14. Make copies of the written test. Add or modify test items as needed.

15. Give written test.

16. Compile assignment sheet ratings and written test scores on the Unit Evaluation Form. Add any additional assignments or supplemental activities that should be part of the unit evaluation.

19. Reteach and retest as required.

Teaching Suggestions

Note: Skill areas appearing in boldface type in the Teaching Suggestions refer to the academic and workplace skills identified by the American Society for Training and Development (ASTD) and the U.S. Department of Labor. These have been adapted by MAVCC.

1. Play "You Inherit" with the students to help them learn place values. Ask students to tell you the least amount they inherit when you give them the amount in numbers of digits. Skill areas: **creative thinking, math**

   Example: Q. "You have just inherited a six-digit sum. What is the least amount you inherit?"

   A. "One hundred thousand dollars."

2. On different tables arrange groups of objects such as screws, nails, outlet boxes, pieces of conductor, tools, and so forth to be added, subtracted, multiplied, divided, stated as a percentage, etc. Have students stop at each table and perform the math procedures indicated. Provide each student with a work sheet on which the equations and answers can be written. Skill area: **math**.

3. Have students play dominoes. Score ends in multiples of five and play to 250, or score ends at the end of each turn and play to 1,000 points. Skill area: **math**.

4. Develop or purchase sets of flashcards for the various math functions. Use the cards to review students in the math functions they need practice with. Skill area: **math**.

Suggested Activities

5. Sit students in a circle. Have all students clap hands twice on legs, then clap hands together twice, then snap fingers twice to establish a rhythm that is to continue unbroken throughout the game. The caller gives a multiplication (or other operation) problem such as 8 x 6 while snapping fingers, and at the next finger snapping says the name of someone to answer the problem. The responder gives the answer at the next finger snapping without breaking the clap/snap rhythm. If the responder breaks the rhythm or gives an incorrect answer, then he or she is out of the game. The last person left is the winner. Skill area: **math**.

6. Have students practice measuring with rules by measuring various items in the classroom or workshop: length of screw, diameter of round box, length of conductor, etc. Have students record their measurements on a sheet of paper, and then have them convert their measurements to improper fractions. After they have improper fractions, have them give their lists to another student who then converts the improper fractions to mixed numbers. Skill area: **math**.

7. Assign monetary values to each letter of the alphabet: A = $.05, B = $.10, C = $.15, D = $.25, E = $1.00 . . . Z = $20.00. Then have students calculate such problems as who has the most valuable name? What electrical component has the most valuable name? What electrical tool has the most valuable name? Skill area: **math**.

8. Obtain a set of twist drills and a drill index. Take the drills out of the drill index. Have the students replace the drills in the index, noting the decimal and fractional differences in drill sizes. Skill area: **math**.

9. Obtain a quantity of pocket-sized decimal equivalent charts from your local tool supplier. Give one to each student. Skill areas: **reading, math**.

10. Ask students questions based on the tables in Chapter 9 and Appendix B of the *National Electrical Code 1993*.

11. Illustrate percentages by providing students with graph or grid paper. Have students outline at least eight 10-by-10 block squares. Since each block contains 100 units or small squares, students can shade in enough units to illustrate 25 percent, 33⅓ percent, 50 percent, 96 percent, and so on.

Resource Used in Developing This Unit

Introduction to Automotive Service, Unit A-4, "Apply Related Math and Measuring." Stillwater, OK: Curriculum and Instructional Materials Center/Oklahoma Department of Vocational and Technical Education, 1989.

Suggested Activities

Suggested Supplemental Resource

Kit: *How to Survive Fractions, Decimals, and Percents*

Note: Print kit includes teacher's guide, two answer key booklets, heavy duty activity cards, and storage case. The software kit includes 400 math word problems in fractions, decimals, and percents to supplement the print kit. Order from EBSCO Curriculum Materials, Division of EBSCO Industries, Inc., Box 281, Chelsea, AL 35043-0281, or call 1-800-633-8623.

Instructions for Evaluating Student Performance

When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in either the teacher guide or student manual. Then observe the student performing the procedure.

> Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily achieved the step(s) for each checkpoint area. If the student is unable to correctly complete the procedure, have the student review the materials and try again.
>
> Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria which have been provided as part of the job sheet. Complete the rating by assigning a point value to each criterion and by converting the point total to a percentage for grading. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) which best fits your program needs.

Option A

4 - Skilled—Can perform job with no additional training.
3 - Moderately skilled—Has performed job during training program; limited additional training may be required.
2 - Limited skill—Has performed job during training program; additional training is required to develop skill.
1 - Unskilled—Is familiar with process, but is unable to perform job.

Option B

Yes—Can perform job with no additional training.

No—Is unable to perform job satisfactorily.

Related Math and Measuring
Unit 17

Answers to Assignment Sheets

Assignment Sheet 1

A.	1.	11	5.	108	9.	1,197
	2.	16	6.	88	10.	16,430
	3.	13	7.	242		
	4.	23	8.	1,538		

B.	1.	20	5.	86	9.	282
	2.	84	6.	53	10.	108
	3.	1135	7.	31		
	4.	$609	8.	423		

Assignment Sheet 2

A.	1.	4	5.	424	9.	51,450
	2.	7	6.	283	10.	89,722
	3.	53	7.	1,175		
	4.	406	8.	1,810		

B.	1.	126	4.	948	7.	210
	2.	12	5.	38	8.	8
	3.	22	6.	142	9.	113

10. Week 1 = 780 km
Week 2 = 1089 km
Week 3 = 1988 km
Week 4 = 1089 km
Week 5 = 1936 km

Assignment Sheet 3

A.	1.	42	5.	8,410	9.	503,605
	2.	72	6.	2,028	10.	5,458,852
	3.	324	7.	21,291		
	4.	2,884	8.	165,478		

B.	1.	32	5.	128	9.	1,440
	2.	96	6.	$348	10.	15,042
	3.	3,000	7.	315		
	4.	24	8.	135		

Answers to Assignment Sheets

Assignment Sheet 4

A.

1. 4
2. 8
3. 91
4. 312
5. 3
6. 3
7. 62, R4
8. 2, R97
9. 1, R365
10. 3, R634

B.

1. 11
2. $22
3. 104
4. 23
5. $936
6. 33

Assignment Sheet 5

A. $\frac{1}{2}$
B. $\frac{1}{2}$
C. 1
D. $\frac{1}{4}$
E. $\frac{1}{4}$
F. $\frac{3}{8}$
G. $\frac{1}{2}$
H. $\frac{1}{2}$
I. $\frac{3}{4}$
J. $\frac{1}{2}$

Assignment Sheet 6

A.

1. P
2. M
3. I
4. M
5. P
6. I
7. I
8. M
9. I
10. M
11. M
12. I
13. I
14. P
15. M

B.

1. $1\frac{3}{4}$
2. $\frac{9}{2}$
3. $\frac{31}{4}$
4. $\frac{17}{2}$
5. $\frac{49}{8}$
6. $\frac{11}{2}$
7. $\frac{17}{4}$
8. $\frac{17}{2}$
9. $\frac{37}{4}$
10. $\frac{33}{2}$

C.

1. $1\frac{3}{4}$
2. $4\frac{1}{2}$
3. $1\frac{1}{2}$
4. $1\frac{7}{8}$
5. $1\frac{3}{16}$
6. $1\frac{3}{8}$
7. $2\frac{11}{32}$
8. $2\frac{1}{2}$
9. $3\frac{3}{4}$
10. $2\frac{1}{16}$

Assignment Sheet 7

A.

1. $\frac{3}{4}$
2. $1\frac{1}{2}$
3. $\frac{1}{2}$
4. 1
5. $1\frac{3}{16}$
6. $\frac{25}{32}$
7. $\frac{29}{32}$
8. $1\frac{1}{4}$
9. $1\frac{5}{16}$
10. $1\frac{25}{32}$

B.

1. $14\frac{3}{4}$
2. $7\frac{3}{4}$
3. $7\frac{3}{16}$
4. $19\frac{5}{8}$
5. $13\frac{1}{16}$
6. $60\frac{1}{16}$
7. $6\frac{13}{16}$
8. $4\frac{1}{4}$
9. $17\frac{1}{16}$

Answers to Assignment Sheets

Assignment Sheet 8

A.
1. 9/16
2. 5/8
3. 3/16
4. 5/32
5. 3/4
6. 9/16
7. 1/16
8. 3/8
9. 17/32
10. 1/2

B.
1. 3 1/4
2. 6 1/16
3. 31 19/32
4. 174 1/5
5. 11 3/64

C.
1. 2/3
2. 1 5/8
3. 8 1/8
4. 1 11/32
5. 25 11/16
6. 7 1/4
7. 9/16
8. 1 1/16
9. 2/3
10. 38 9/16

D.
1. 2/5
2. 49 15/16
3. 5 2/3
4. 9 1/2
5. 27 1/8
6. 2 1/4
7. 2 1/8
8. 3 5/16
9. 2 1/2
10. 3 3/16

E.
1. 1/8
2. 3/4
3. 2 7/8
4. 10
5. 1 3/8
6. 6 11/20
7. 3 3/4
8. 8 5/8

Assignment Sheet 9

A.
1. 3/8
2. 15/128
3. 3 3/8
4. 3 1/4
5. 7/12
6. 1 1/2
7. 1/24
8. 16 27/32

B.
1. 1/4 gallon
2. 74 screws
3. 4 1/3 wires

Assignment Sheet 10

A.
1. Tenths
2. Hundredths
3. Hundred thousandths
4. Ten thousandths
5. Thousandths

Answers to Assignment Sheets

B.
1. Hundredths
2. Ten thousandths
3. Tenths
4. Thousandths
5. Hundredths

C.

1.	$46.3\underline{8}26$	8.	$208.0\underline{9}7$	15.	$52.69\underline{4}$
2.	$35.003\underline{8}$	9.	$5.23\underline{9}81$	16.	$498.\underline{2}76$
3.	$148.\underline{2}96$	10.	$502.\underline{9}67$	17.	$0.529\underline{6}$
4.	$6758.2\underline{3}$	11.	$5230.86\underline{7}$	18.	$\underline{4}68.539$
5.	$91.40\underline{8}2$	12.	$58\underline{7}.029$	19.	$324.\underline{0}6$
6.	$2\underline{0}4.37$	13.	$0.2\underline{9}8$	20.	$56\underline{7}.8$
7.	$1\underline{4}.0079$	14.	$3\underline{2}9.768$		

D.

1.
$$\begin{array}{r} 0.024 \\ \underline{+\ 0.165} \\ 0.189 \end{array}$$

2.
$$\begin{array}{r} 87.3 \\ \underline{+\ 370.0} \\ 457.3 \end{array}$$

3.
$$\begin{array}{r} 15.127 \\ 3.4 \\ .0091 \\ \underline{+\ 236.87} \\ 255.4061 \end{array}$$

4.
$$\begin{array}{r} 195.7 \\ 83.0 \\ \underline{+\ \ 9.0006} \\ 287.706 \end{array}$$

5.
$$\begin{array}{r} .5280 \\ 435. \\ 179.50 \\ \underline{+\ \ 1.9} \\ 616.9280 \end{array}$$

E.

1.	$39.00	4.	20.1
2.	$74.33	5.	$16,018.26
3.	23.9		

Assignment Sheet 11

A.

1.	351.98	4.	508.16	7.	670.4	10.	$197.45
2.	547.144	5.	$749.25	8.	4,107.34		
3.	141.013	6.	$4.15	9.	$2.47		

B.

1.	$3317.32	4.	40.5
2.	14.5	5.	27.5
3.	2.84		

1030

Answers to Assignment Sheets

Assignment Sheet 12

A.
1. 8.184
2. 39.6
3. 1.1475
4. 297.5
5. 100.32
6. 6.4584
7. 0.4565
8. 25.38
9. 0.00069
10. 22.6352

B.
1. $337.45
2. $6187.50
3. .78
4. .28
5. $16.95
6. $18.72
7. 188.6
8. 336

Assignment Sheet 13

A.
1. 9
2. 12.4
3. 33
4. 153
5. 1.5
6. 284
7. 0.8
8. 0.5
9. 300
10. 0.4

B.
1. $8.64
2. 30.3
3. 32
4. $21.60
5. $4.78

Assignment Sheet 14

A.
1. 0.125
2. 0.25
3. 0.5
4. 0.75
5. 0.625
6. 0.0625
7. 0.09375
8. 0.875
9. 0.5625
10. 0.9375

B.
1. 25%
2. 50%
3. 70%
4. 75%
5. 100%
6. 10%
7. 87.5%
8. 50%
9. 33.3%
10. 62.5%

C.
1. g
2. j
3. d
4. a
5. i
6. b
7. c
8. f
9. h
10. e

D.
1. 63.9
2. 5.93
3. 5.093
4. 5.0093
5. 3.825
6. 38.95
7. 38.095
8. 43.3
9. 402.3
10. 897.00097

E.
1. ½
2. ¼
3. ⅓
4. 9/25
5. 7/25
6. 1/7
7. 21/100
8. ¾
9. ⅔
10. 7/10

F.
1. .47
2. .15
3. .333
4. .62
5. .75
6. .03
7. .168
8. .09
9. .10
10. .50

Answers to Assignment Sheets

Assignment Sheet 15

A. All work completed
B. 14%
C. 86, 86%
D. 25%, 5%
E. 94%
F. 6, 6%
G. 89%
H. 94%
I. 40%
J. 50%
K. 5%
L. 38%
M. 25%
N. 60%
O. 7%

P.
  1. 2.16
  2. 0.9
  3. 32
  4. 50
  5. 43.18
  6. 17.6
  7. 1.03
  8. 57
  9. 16.4
  10. 11.41

Q.
  1. 12
  2. 1
  3. $24.00
  4. 600

Assignment Sheet 16

A.
  1. 64 square inches
  2. 256 square feet
  3. 225 square feet
  4. 1,296 square yards

B.
  1. 60 square feet
  2. 192 square yards
  3. 527 square inches
  4. 992 square feet

C.
  1. 113.04 square inches
  2. 615.44 square feet
  3. 803.84 square feet
  4. 490.625 square yards

D.
  1. 48 square inches
  2. 199.5 square feet
  3. 19.5 square inches
  4. 180 square yards

E.
  1. 12 square feet
  2. 104 square yards
  3. 256 square inches
  4. 243 square yards

F.
  1. 493 square inches
  2. 242 square yards
  3. 168 square feet
  4. 765 square yards

Related Math and Measuring
Unit 17

Answers to Pretest

1. a, c, f, h, i, k, l

2.
a. 10
b. 2
c. 6
d. 5
e. 4
f. 8
g. 3
h. 7
i. 1
j. 9

3.
a. Millions
b. Hundred thousands
c. Ten thousands
d. Thousands
e. Hundreds
f. Tens
g. Units

4.
a. 18
b. 30
c. 399

5.
a. 5
b. 25
c. 255

6.
a. 18
b. 4200
c. 58512

7.
a. 32
b. 4
c. 4 with 1 R

8.
a. I
b. P
c. P
d. M
e. I

9.
a. ¼
b. ⅛
c. ⅕
d. ¼
e. ⅑

Answers to Pretest

10. a. $\frac{9}{4}$
    b. $\frac{55}{8}$
    c. $\frac{155}{10}$

11. a. $6\frac{3}{4}$
    b. $7\frac{7}{8}$
    c. $36\frac{5}{6}$

12. a. $\frac{7}{8}$
    b. $5\frac{11}{16}$
    c. $12\frac{9}{16}$

13. a. $\frac{1}{4}$
    b. $\frac{9}{16}$
    c. $1\frac{7}{16}$

14. a. $\frac{15}{32}$
    b. $1\frac{31}{32}$
    c. $23\frac{3}{8}$

15. a. Tenths
    b. Hundredths
    c. Thousandths
    d. Ten thousandths
    e. Hundred thousandths
    f. Millionths

16. a. 12.39
    b. 9.27
    c. 64.0653

17. a. $8.10
    b. 21.024
    c. 0.3533

18. a. 37.75
    b. .11160
    c. 27.699840

19. a. 4.5
    b. 12.5
    c. 847.5

1034

20. a. $\frac{2}{25}$
    b. $\frac{7}{20}$
    c. $\frac{21}{25}$

Answers to Pretest

21. a. 0.75; 75%
    b. .3572; 36%
    c. 26.06; 2606%

22. a. 0.15; $\frac{3}{20}$
    b. 0.40; $\frac{2}{5}$
    c. 1.25; $1\frac{1}{4}$

23. a. $30.00
    b. 2040 fixtures
    c. 20 percent

24.	a.	T	e.	T	i.	F	m.	T
	b.	F	f.	F	j.	T	n.	F
	c.	T	g.	F	k.	T		
	d.	F	h.	F	l.	F		

25.	a.	2	e.	1
	b.	3	f.	1
	c.	2	g.	1
	d.	3		

26.	a.	4	d.	5
	b.	6	e.	1
	c.	2	f.	3

27. a. 128 sq. in.
    b. 300 sq. yd.
    c. 225 sq. in.
    d. 51 sq. in.
    e. $157\frac{1}{2}$ sq. yd.

28. a. $\frac{15}{16}$
    b. $\frac{5}{16}$

29. a. 5m
    b. 37mm
    c. 50.5mm

30.	a.	948	g.	11	m.	$2\frac{3}{4}$	s.	$6187.50
	b.	38	h.	3000	n.	$\frac{1}{16}$	t.	$132.62
	c.	17	i.	$7\frac{3}{4}$	o.	74.33	u.	$348
	d.	1135	j.	$8\frac{1}{4}$	p.	41,018.26	v.	$19
	e.	315	k.	$7\frac{3}{16}$	q.	$3317.32	w.	$54
	f.	104	l.	$\frac{1}{8}$	r.	14.5	x.	8.2

Related Math and Measuring
Unit 17

Answers to Written Test

1. a. 7
   b. 12
   c. 1
   d. 11
   e. 8
   f. 6
   g. 2
   h. 4
   i. 13
   j. 3
   k. 10
   l. 9
   m. 5

2. a. 10
   b. 2
   c. 6
   d. 5
   e. 4
   f. 8
   g. 3
   h. 7
   i. 1
   j. 9

3. a. Millions
   b. Hundred thousands
   c. Ten thousands
   d. Thousands
   e. Hundreds
   f. Tens
   g. Units

4. a. 11
   b. 20
   c. 128
   d. 1,797
   e. 21,085

5. a. 2
   b. 26
   c. 402
   d. 342
   e. 1,119

6. a. 35
   b. 612
   c. 49,980
   d. 348,513
   e. 5,568,066

7. a. 12
   b. 4
   c. 16
   d. 2
   e. 14, R131
   f. 152, R400

8. a. P
   b. M
   c. I
   d. M
   e. M
   f. P
   g. P
   h. M
   i. P
   j. I

9. a. ½
   b. ½
   c. 7⁄16
   d. ¼
   e. ⅜
   f. ¼
   g. ⅛
   h. ⅛
   i. ¾
   j. 32⁄32

Answers to Written Test

10. a. (1) $\frac{7}{2}$
(2) $\frac{9}{2}$
(3) $\frac{15}{4}$
(4) $\frac{25}{2}$
(5) $\frac{429}{32}$

b. (1) $5\frac{7}{8}$
(2) $2\frac{1}{3}$
(3) $4\frac{16}{23}$
(4) $10\frac{4}{5}$
(5) 16

11. a. $\frac{3}{4}$
b. 1
c. $1\frac{1}{4}$
d. 1
e. 1
f. $1\frac{1}{4}$
g. $9\frac{3}{8}$
h. $19\frac{5}{8}$
i. $12\frac{3}{4}$
j. $11\frac{1}{4}$

12. a. $\frac{1}{8}$
b. $\frac{1}{2}$
c. $\frac{5}{16}$
d. $\frac{1}{8}$
e. $\frac{1}{4}$
f. 0
g. $1\frac{1}{2}$
h. $3\frac{5}{8}$
i. 5
j. $5\frac{5}{8}$

13. a. $\frac{3}{8}$
b. $\frac{9}{32}$
c. $\frac{3}{32}$
d. $4\frac{7}{8}$
e. $59\frac{1}{16}$
f. $10\frac{11}{16}$
g. $24\frac{1}{16}$

14. a. Tenths
b. Hundredths
c. Thousandths
d. Ten thousandths
e. Hundred thousandths
f. Millionths

15. a. 15.6
b. 5.346
c. $20.63
d. 132.003
e. 6735.2613

16. a. $3.90
b. $3.08
c. $6.75
d. 0.585325
e. 0.25

17. a. 12.22
b. 0.00595
c. 0.72
d. 680.58144
e. 7.22

18. a. 13.3
b. 139
c. 31
d. 3.07
e. 0.15
f. 120
g. 600
h. 9,000
i. 14,000
j. 105,375

Answers to Written Test

19. a. (1) 3/50
(2) 11/20
(3) 9/100
(4) 13/20
(5) 37/40

b. (1) 0.12; 3/25
(2) 0.30; 3/10
(3) 0.45; 9/20
(4) 0.72; 18/25
(5) 2.50; 2½

20. a. $22.41
b. 1848 fixtures
c. 20 percent

21. a. 9
b. 7
c. 14
d. 1
e. 13
f. 10
g. 6
h. 8
i. 2
j. 4
k. 5
l. 3
m. 12
n. 11

22. a. 4
b. 7
c. 1
d. 6
e. 3
f. 5
g. 2

23. a. 5
b. 1
c. 3
d. 6
e. 4
f. 2

24. a. 900 square feet
b. 452.16 square yards
c. 18 square inches
d. 112 square miles
e. 8,704 square miles
f. 16¼ square rods

25. a. 3
b. 5
c. 4
d. 6
e. 2
f. 1

26. English rule

a. 15/16"
b. 1⅞"
c. 2¾"
d. 3 5/16"
e. 4½"

Metric rule

a. 5mm
b. 37mm
c. 62mm
d. 69.5mm
e. 33.5mm

Related Math and Measuring
Unit 17

Pretest

Name ______________________________ Score ______________

1. Select correct definitions of math terms. Write a "T" in the blank before each correct definition.

   ______a. **Fraction** is part of a whole; it represents one or more equal parts of a unit.

   ______b. **Digit** is any of the natural numbers, both positive and negative, that represents a complete item.

   ______c. **Subtraction** is the opposite (inverse) operation of addition.

   ______d. **Whole number (integer)** is any of the ten symbols, 0 to 9, by which all numbers can be expressed.

   ______e. **Percent** is a fraction with an unwritten denominator of 10 or some power of 10; indicated with a point before the number.

   ______f. **Multiplication** is an abbreviated process of adding a number to itself a specified number of times.

   ______g. **Decimal** is one part in a hundred; reckoned on the basis of a whole divided into one hundred parts.

   ______h. **Division** is the opposite (inverse) operation of multiplication.

   ______i. **Liter** is the metric unit used to measure capacity.

   ______j. **Ratio** is being relatively equal in size or quantity.

   ______k. **Addition** is the process of totaling two or more numbers to find another number called a sum.

   ______l. **Meter** is the metric unit used to measure length.

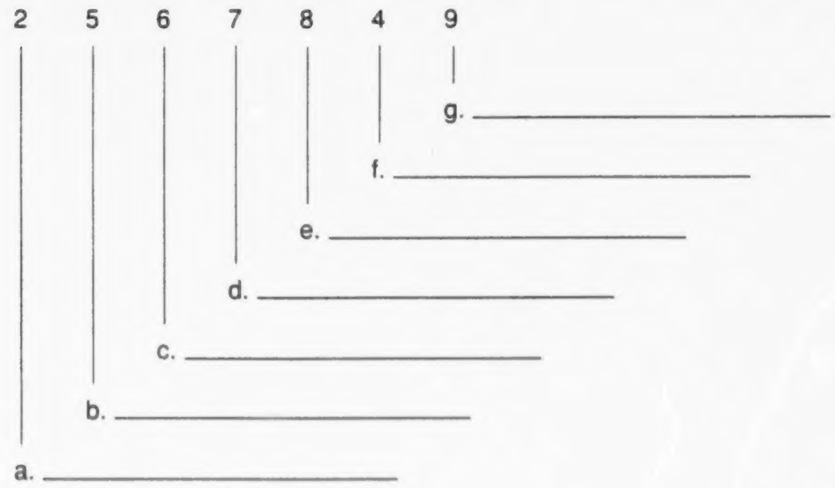
   ______m. **Proportional** is the relationship in quantity, amount, or size between two or more things.

Pretest

2. Match symbols used in basic math with their correct names. Write the correct numbers in the blanks.

______a.	Plus sign (addition)	1. .
______b.	Pi sign	2. π
______c.	Equal sign	3. %
______d.	Division frame	4. :
______e.	Ratio symbol	5. ⟌
______f.	Minus sign (subtraction)	6. =
______g.	Percent symbol	7. x
______h.	Times sign (multiplication)	8. –
______i.	Decimal point	9. ÷
______j.	Division sign	10. +

3. Label the place values in the whole number below.


2 5 6 7 8 4 9
g. ______________________
f. ______________________
e. ______________________
d. ______________________
c. ______________________
b. ______________________
a. ______________________

Pretest

4. Add whole numbers to solve the following problems.

a. $\begin{array}{r} 7 \\ \underline{+\ 11} \end{array}$ b. $\begin{array}{r} 5 \\ 10 \\ \underline{+\ 15} \end{array}$ c. $\begin{array}{r} 40 \\ 159 \\ \underline{+\ 200} \end{array}$

5. Subtract whole numbers to solve the following problems.

a. $\begin{array}{r} 8 \\ \underline{-\ 3} \end{array}$ b. $\begin{array}{r} 47 \\ \underline{-\ 22} \end{array}$ c. $\begin{array}{r} 477 \\ \underline{-\ 222} \end{array}$

6. Multiply whole numbers to solve the following problems.

a. $\begin{array}{r} 6 \\ \underline{\times\ 3} \end{array}$ b. $\begin{array}{r} 75 \\ \underline{\times\ 56} \end{array}$ c. $\begin{array}{r} 424 \\ \underline{\times\ 138} \end{array}$

7. Divide whole numbers to solve the following problems.

a. $3\overline{)96}$ b. $24\overline{)96}$ c. $135\overline{)541}$

8. Distinguish among types of fractions. Write a "P" in the blanks before proper fractions, an "I" before improper fractions, and an "M" before mixed numbers.

_______a. $\frac{5}{3}$ _______c. $\frac{20}{100}$ _______e. $\frac{5}{5}$

_______b. $\frac{3}{8}$ _______d. $1\frac{3}{15}$

9. Reduce the following fractions to lowest terms. Write your answers in the blanks.

_______a. $\frac{2}{8}$ _______c. $\frac{5}{8}$ _______e. $\frac{5}{81}$

_______b. $\frac{4}{32}$ _______d. $\frac{8}{32}$

Pretest

10. Convert the following mixed numbers to improper fractions. Reduce to lowest terms. Write your answers in the blanks.

_______a. $2\frac{1}{4}$

_______b. $6\frac{7}{8}$

_______c. $15\frac{5}{10}$

11. Convert the following improper fractions to mixed numbers. Reduce to lowest terms. Write your answers in the blanks.

_______a. $\frac{27}{4}$

_______b. $\frac{63}{8}$

_______c. $\frac{221}{6}$

12. Add fractions to solve the following problems. Convert to mixed numbers if necessary, and reduce to lowest terms. Write your answers in the blanks.

_______a. $\frac{2}{8} + \frac{5}{8}$

_______b. $\frac{7}{16} + 5\frac{1}{4}$

_______c. $4\frac{1}{2} + 8\frac{1}{16}$

13. Subtract fractions to solve the following problems. Reduce answers to lowest terms. Write your answers in the blanks.

_______a. $\frac{5}{8} - \frac{3}{8}$

_______b. $\frac{15}{16} - \frac{3}{8}$

_______c. $3\frac{5}{8} - 2\frac{3}{16}$

14. Multiply fractions to solve the following problems. Reduce to lowest terms. Write your answers in the blanks.

_______a. $\frac{3}{4} \times \frac{5}{8}$

_______b. $\frac{3}{8} \times 5\frac{1}{4}$

_______c. $8\frac{1}{2} \times 2\frac{3}{4}$

1042

Pretest

15. Label the place values in the decimal number below.

0. 0 8 7 1 6 4

f. ______________________________

e. ______________________________

d. ______________________________

c. ______________________________

b. ______________________________

a. ______________________________

16. Add decimal numbers to solve the following problems. Write your answers in the blanks.

______a. $7.32 + $.68 + $4.39

______b. 8.40 + 0.87

______c. 64.018 + .0473

17. Subtract decimal numbers to solve the following problems.

______a. $16.20 – $8.10

______b. 41.032 – 20.008

______c. 0.7964 – 0.4431

18. Multiply decimal numbers to solve the following problems.

______a. 4.5 × 7.5

______b. .248 × 00.45

______c. 8.064 × 3.435

Pretest

19. Divide decimals to solve the following problems. Write your answers in the blanks.

______a. 3.15 ÷ 0.7

______b. 6.25 ÷ 0.05

______c. 72 ÷ .085

20. Convert the following decimal fractions to common fractions. Write your answers in the blanks.

______a. .8

______b. .35

______c. .840

21. Convert the following common fractions to decimal numbers and percentages. Give percentages in the nearest whole percent. Write your answers in the blanks.

Decimals	Percentages		
______	______	a.	$\frac{3}{4}$
______	______	b.	$\frac{5}{14}$
______	______	c.	$26\frac{6}{100}$

22. Convert the following percentages to fractions and decimal numbers. Write your answers in the blanks.

Decimals	Percentages		
______	______	a.	15%
______	______	b.	40%
______	______	c.	125%

Pretest

23. Solve the following percentage problems. Write your answers in the blanks.

_____a. If a contractor paid an electrician $150 which is 80 percent of her salary, how much more money would the contractor still owe?

_____b. If 15 percent of the fixtures are stolen, how many fixtures will be left of the 2400 stored for the job?

_____c. If Ed bought equipment for $48,000 and sold it for $60,000 what was his percentage of profit?

24. Match terms used in geometry to their correct definitions. Write "T" or "F" in the blanks.

_____a. **Cubic unit** is a unit with three equal dimensions including length, width, and height.

_____b. **Perimeter** is a line or surface at a right angle to another line or surface.

_____c. **Geometric figure** is a shape formed by straight or curved lines.

_____d. **Area** is the volume of an object that is 1 foot long, 1 foot wide, and 1 foot high.

_____e. **Right angle** is an angle formed by two lines perpendicular to each other; it is also a 90-degree angle.

_____f. **Circumference** is the outer limits or boundary.

_____g. **Perpendicular** is relating to, consisting of, or resembling a straight line.

_____h. **Cubic foot** is the measure of a flat surface; it is expressed in square units.

_____i. **Lineal** is the distance around the outer edge of a circle.

_____j. **Parallel** means lines or surfaces extending in the same direction an equal distance apart and never meeting.

_____k. **Pi** is a Greek letter (π) representing the ratio of a circle's circumference to its diameter; the ratio is approximately 3.1416.

_____l. **Diameter** is a line from the center of a circle to any point on the edge of a circle.

_____m. **Volume** is space occupied by a body; it is expressed in cubic units.

_____n. **Radius** is the distance between the outer edges of a circle through its center point.

1045

Pretest

25. Match types of geometric figures to their correct descriptions. Select your answer from the three listed and write the correct numbers in the blanks.

_____a.	Figure—such as a square, rectangle, or rhombus—with two parallel ends of equal length and two parallel sides of equal length	1. Trapezoid 2. Parallelogram 3. Rhombus
_____b.	Figure with only one pair of parallel opposite sides	1. Triangle 2. Parallelogram 3. Trapezoid
_____c.	Figure having four sides of equal length and four right angles	1. Rhombus 2. Square 3. Rectangle
_____d.	Flat figure formed by one curved line; all points of line are equidistant from center point	1. Sphere 2. Curve 3. Circle
_____e.	Figure with two parallel ends of equal length, two parallel sides of equal length, and four right angles	1. Rectangle 2. Square 3. Rhombus
_____f.	Figure having no right angles and four sides of equal length	1. Rhombus 2. Trapezoid 3. Parallelogram
_____g.	Figure having three sides and three angles	1. Triangle 2. Circle 3. Rhombus

Pretest

26. Match units of measure to their correct equivalents. Write the correct numbers in the blanks.

______a. Equal to twelve inches (12″) or one third of a yard (⅓ yard)

______b. Equal to sixteen and one-half feet (16½′)

______c. Equal to five thousand, two hundred and eighty feet (5,280′)

______d. Equal to one-twelfth of a foot (1/12′) or one thirty-sixth of a yard (1/36 yard)

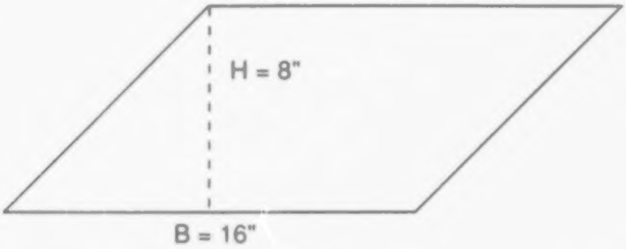
______e. Equal to three feet (3′) or thirty-six inches (36″)

______f. Equal to 1/360 of a circle

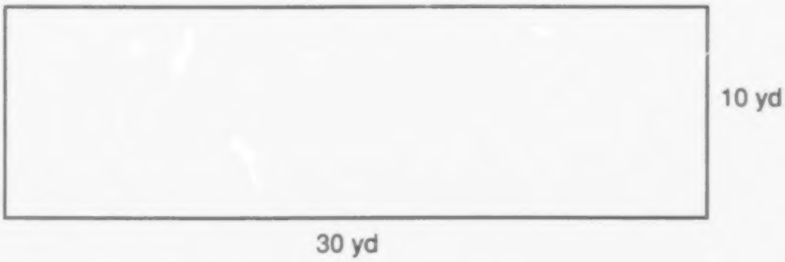
1. Yard
2. Mile
3. Degree (°)
4. Foot (′)
5. Inch (″)
6. Rod

27. Calculate area of the following geometric figures. Write the correct answers in the blanks.

______a.

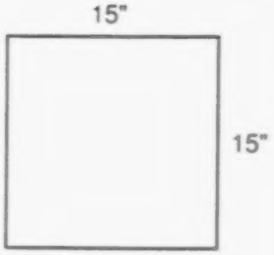


______b.

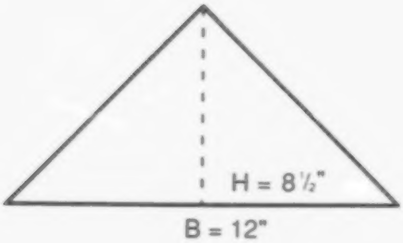


Pretest

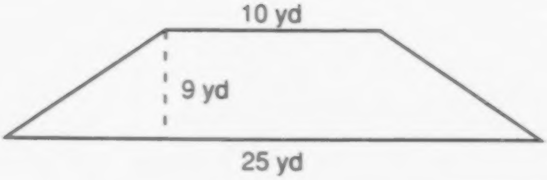
_____c.



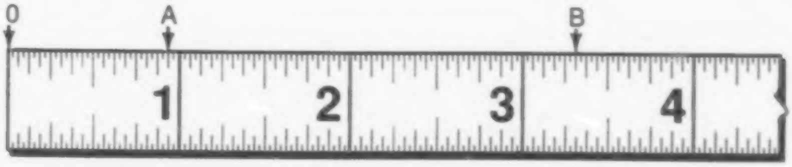
_____d.



_____e.


10 yd
9 yd
25 yd

28. Read the rule illustrated below to the nearest sixteenth inch. Write your answers in the blanks provided.

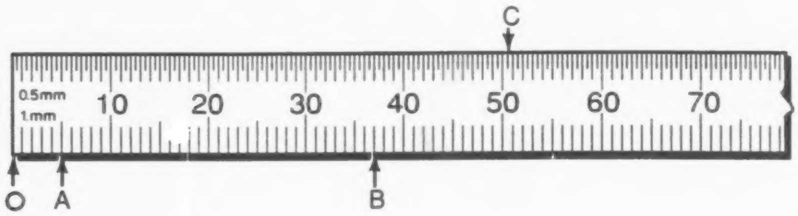


a. 0 to A = _____

b. 0 to B = _____

Pretest

29. Read the metric rule illustrated below to the nearest 0.5 millimeter. Write your answers in the blanks provided.



a. 0 to A = ______

b. 0 to B = ______

c. 0 to C = ______

30. Solve the following story problems. Write your answers in the blanks.

______a. In the first year of operation, an electrical shop handled 1219 jobs. During the second year, the number of jobs increased to 2167. How many more jobs did the shop handle the second year?

______b. To install three hanging lights over a kitchen counter takes 65 minutes. If you have already worked 27 minutes, how much longer will you need to work?

______c. An electrician has 9 boxes for replacement when needed. He has ordered and received 8 additional boxes. How many total boxes does he have in stock?

______d. An electrician ordered the following number of caps at different dates: 256, 62, 575, and 242. How many caps should she be billed for?

______e. It takes 35 minutes to wire a fixture in one home. How many minutes does it take to perform the same job on 9 homes?

______f. How many 4-conductor ducts can be made using a bundle containing 416 conductors of the desired length?

______g. If a can of lubricant holds 5 pounds, how many cans may be filled from a 55-pound drum?

1049

Pretest

______h. There are 500 bolts in a box. How many are in 6 boxes?

______i. What is the combined length of two bolts that measure $3\frac{1}{2}$ inches and $4\frac{1}{4}$ inches?

______j. Samuel worked $4\frac{1}{2}$ hours before lunch and $4\frac{3}{4}$ hours after lunch. How many hours did Samuel work?

______k. What is the combined length of three tools measuring $2\frac{1}{8}$ inches, $3\frac{1}{4}$ inches, and $1\frac{13}{16}$ inches?

______l. Sarah had a $\frac{7}{8}$-inch wrench. She needed a $\frac{3}{4}$-inch wrench. How much difference is there in the size of the wrenches?

______m. $5\frac{1}{4}$ hours are how many more than $2\frac{1}{2}$ hours?

______n. If you had to reduce a $\frac{15}{16}$-inch part by $\frac{7}{8}$ inch, how much would you have to reduce it?

______o. On a lighting job, fixture parts cost $54.65, labor costs $16.30, and tax costs $3.38. What is the total cost of the job?

______p. In one month, an electrical repair shop had the following expenses: fixtures and supplies, $429.33; electric bill, $160.16; telephone, $116.27; and labor, $40,312.50. What was the shop's monthly expenditure?

______q. An electrical shop received $8438.64 this month and paid out $5121.32. How much profit did the shop make?

______r. It takes 20.5 hours to finish a job. Mary has worked 6 hours. How many hours will it take her to finish the job?

______s. The average cost of a GFCI installation is $41.25. During the year, the technician installs 150 GFCIs. What was the total cost?

______t. A specialist buys 38 box hangers at a cost of $3.49 each. What is the total cost?

______u. If a can of lubricating grease costs $6.00 per pound, how much will 58 pounds of grease cost?

______v. Naoki received $361.00 for a wiring job. He worked 19 hours on the job. How much did he make per hour?

Pretest

______w. An apprentice electrician is paid $729.00 for 13.5 weeks of work. Find the average earnings per week for the apprentice.

______x. If wiring can be installed in 32 homes in 3.9 days, how many homes can be serviced in 1 day? Round your answer to the nearest tenth.

*Permission to duplicate this test is granted.

Related Math and Measuring
Unit 17

Written Test

Name ______________________________ Score ______________

1. Match terms associated with math and measuring to their correct definitions. Write the correct numbers in the blanks.

______a. Process of totaling two or more numbers to find another number called a sum

______b. Fraction with an unwritten denominator of 10 or some power of 10; indicated with a point before the number

______c. Any one of the ten symbols, 0 to 9, by which all numbers can be expressed

______d. Opposite (inverse) operation of multiplication

______e. Part of a whole; represents one or more equal parts of a unit

______f. Any of the natural numbers, both positive and negative, that represents a complete item

______g. Abbreviated process of adding a number to itself a specified number of times

______h. Metric unit used to measure capacity

______i. One part in a hundred; reckoned on the basis of a whole divided into one hundred parts

______j. Metric unit used to measure length

______k. Being relatively equal in size or quantity

______l. Relationship in quantity, amount, or size between two or more things

______m. Opposite (inverse) operation of addition

1. Digit
2. Multiplication
3. Meter
4. Liter
5. Subtraction
6. Whole number (integer)
7. Addition
8. Fraction
9. Ratio
10. Proportional
11. Division
12. Decimal
13. Percent

Written Test

2. Match symbols used in math problems with their names. Write the correct numbers in the blanks.

_____a. Plus sign (addition)

_____b. Pi sign

_____c. Equal sign

_____d. Division frame

_____e. Ratio symbol

_____f. Minus sign (subtraction)

_____g. Percent symbol

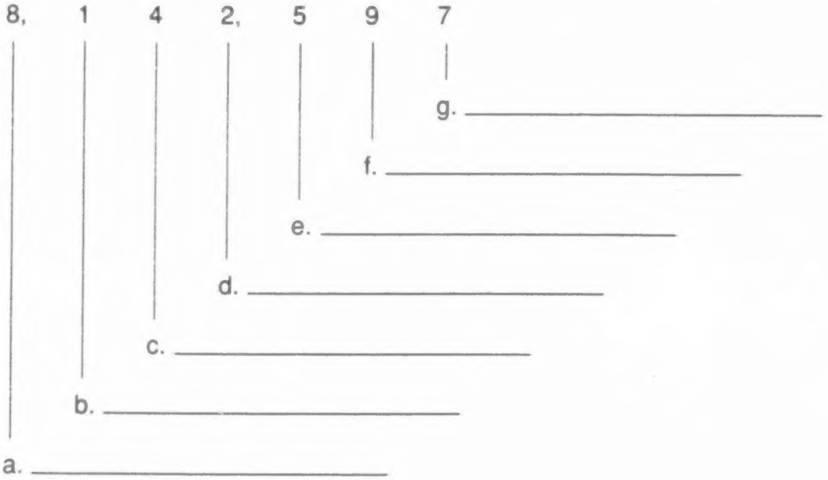
_____h. Times sign (multiplication)

_____i. Decimal point

_____j. Division sign

1. .
2. π
3. %
4. :
5. $\overline{)\quad}$
6. =
7. x
8. –
9. ÷
10. +

3. Label the place values of the whole number below.



g. ______________________________

f. ______________________________

e. ______________________________

d. ______________________________

c. ______________________________

b. ______________________________

a. ______________________________

Written Test

4. Add whole numbers to solve the following problems. Show your work.

   a. $\begin{array}{r} 2 \\ \underline{+\ 9} \end{array}$ b. $\begin{array}{r} 5 \\ 7 \\ \underline{+\ 8} \end{array}$ c. $\begin{array}{r} 12 \\ 17 \\ \underline{+\ 99} \end{array}$ d. $\begin{array}{r} 142 \\ 759 \\ \underline{+\ 896} \end{array}$ e. $\begin{array}{r} 2345 \\ 9764 \\ \underline{+\ 8976} \end{array}$

5. Subtract whole numbers to solve the following problems. Check your answers and show your work.

   a. $\begin{array}{r} 9 \\ \underline{-\ 7} \end{array}$ b. $\begin{array}{r} 35 \\ \underline{-\ 9} \end{array}$ c. $\begin{array}{r} 481 \\ \underline{-\ 79} \end{array}$ d. $\begin{array}{r} 684 \\ \underline{-\ 342} \end{array}$ e. $\begin{array}{r} 9867 \\ \underline{-\ 8748} \end{array}$

6. Multiply whole numbers to solve the following problems. Show your work.

   a. $\begin{array}{r} 7 \\ \underline{\times\ 5} \end{array}$ b. $\begin{array}{r} 68 \\ \underline{\times\ 9} \end{array}$ c. $\begin{array}{r} 735 \\ \underline{\times\ 68} \end{array}$ d. $\begin{array}{r} 649 \\ \underline{\times\ 537} \end{array}$ e. $\begin{array}{r} 8673 \\ \underline{\times\ 642} \end{array}$

7. Divide whole numbers to solve the following problems. Show your work.

   a. $4\overline{)48}$ b. $16\overline{)64}$ c. $38\overline{)608}$

   d. $421\overline{)842}$ e. $317\overline{)4569}$ f. $530\overline{)80960}$

Written Test

8. Distinguish among types of fractions. Write a "P" in the blanks before proper fractions, an "I" before improper fractions, and an "M" in the blanks before mixed numbers.

_____a. $1/2$

_____b. $8\,3/4$

_____c. $8/8$

_____d. $15\,3/8$

_____e. $5\,3/16$

_____f. $10/32$

_____g. $2/8$

_____h. $6\,1/2$

_____i. $1/4$

_____j. $99/1$

9. Reduce the following fractions to lowest terms. Write your answers in the blanks.

_____a. $4/8$

_____b. $8/16$

_____c. $7/16$

_____d. $8/32$

_____e. $12/32$

_____f. $4/16$

_____g. $2/16$

_____h. $8/64$

_____i. $12/16$

_____j. $31/32$

10. Convert the following fractions and mixed numbers.

a. Convert to improper fractions. Reduce to lowest terms if possible. Write your answers in the blanks.

_____(1) $3\frac{1}{2}$

_____(2) $4\frac{2}{4}$

_____(3) $3\frac{6}{8}$

_____(4) $12\frac{4}{8}$

_____(5) $13\frac{13}{32}$

1055

b. Convert to mixed numbers. Reduce answers to lowest terms. Write your answers in the blanks.

______(1) $\frac{47}{8}$

______(2) $\frac{21}{9}$

______(3) $\frac{108}{23}$

______(4) $\frac{54}{5}$

______(5) $\frac{112}{7}$

11. Add fractions to solve the following problems. Convert to mixed numbers if necessary, and reduce to lowest terms. Write your answers in the blanks.

______a. $\frac{1}{8} + \frac{5}{8}$

______b. $\frac{1}{16} + \frac{15}{16}$

______c. $\frac{2}{4} + \frac{3}{4}$

______d. $\frac{1}{2} + \frac{4}{8}$

______e. $\frac{4}{8} + \frac{2}{4}$

______f. $\frac{7}{8} + \frac{6}{16}$

______g. $2\frac{1}{8} + 7\frac{1}{4}$

______h. $3\frac{2}{4} + 16\frac{1}{8}$

______i. $4\frac{2}{4} + 8\frac{2}{8}$

______j. $5\frac{1}{8} + 6\frac{2}{16}$

Written Test

12. Subtract fractions to solve the following problems. Reduce answers to lowest terms. Write your answers in the blanks.

______a. $\frac{4}{8} - \frac{3}{8}$

______b. $\frac{6}{8} - \frac{2}{8}$

______c. $\frac{9}{16} - \frac{4}{16}$

______d. $\frac{3}{8} - \frac{1}{4}$

______e. $\frac{3}{8} - \frac{1}{8}$

______f. $\frac{14}{16} - \frac{7}{8}$

______g. $2\frac{3}{4} - 1\frac{1}{4}$

______h. $6\frac{1}{8} - 2\frac{1}{2}$

______i. $9\frac{2}{4} - 4\frac{1}{2}$

______j. $12\frac{6}{8} - \frac{71}{8}$

13. Multiply fractions to solve the following problems. Reduce to lowest terms. Write your answers in the blanks.

______a. $\frac{1}{2} \times \frac{3}{4}$

______b. $\frac{3}{4} \times \frac{3}{8}$

______c. $\frac{3}{2} \times \frac{1}{16}$

______d. $\frac{3}{4} \times 6\frac{1}{2}$

______e. $6\frac{3}{4} \times 8\frac{3}{4}$

______f. $7\frac{1}{8} \times 1\frac{1}{2}$

______g. $\frac{77}{16} \times 5$

Written Test

14. Label the place values in the decimal number below.

0. 0 8 7 1 6 4

f. ______________________

e. ______________________

d. ______________________

c. ______________________

b. ______________________

a. ______________________

15. Add decimal numbers to solve the following problems. Set up each problem and show your work. Write your answers in the blanks.

______a. 3.5 + 5.1 + 7

______b. 3.4 + 0.206 + 1.74

______c. $6.86 + $5.05 + $7.90 + $.82

______d. 57.78 + 0.22 + 0.003 + 74

______e. 6319 + 95.12 + 0.0713 + 321.07

Written Test

16. Subtract decimal numbers to solve the following problems. Set up each problem and check your work. Write your answers in the blanks.

______a. $6.10 - $2.20

______b. $5.40 - $2.32

______c. $7.38 - $.63

______d. 0.835325 - 0.25

______e. 0.609375 - 0.359375

17. Multiply decimal numbers to solve the following problems. Set up each problem and show your work. Write your answers in the blanks.

______a. 2.6 × 4.7

______b. 0.119 × 0.05

______c. 9 × 0.08

______d. 7.392 × 92.07

______e. 9.5 × 0.76

Written Test

18. Divide decimals to solve the following problems. Set up each problem and check your work. Write your answers in the blanks.

______a. 5.32 ÷ 0.4

______b. 83.4 ÷ 0.6

______c. 7.75 ÷ 0.25

______d. 0.921 ÷ 0.3

______e. 0.0225 ÷ 0.15

______f. 24 ÷ 0.2

______g. 54 ÷ 0.09

______h. 63 ÷ 0.007

______i. 812 ÷ 0.058

______j. 4125 ÷ 0.040

Written Test

19. a. Convert the following decimal fractions to common fractions. Write your answers in the blanks.

______(1) .6

______(2) .55

______(3) .09

______(4) .650

______(5) .925

b. Convert the following percentages to fractions and decimal numbers. Write your answers in the blanks.

Fraction	Decimal	
______________	______________	(1) 12%
______________	______________	(2) 30%
______________	______________	(3) 45%
______________	______________	(4) 72%
______________	______________	(5) 250%

20. Solve the following percentage problems. Write your answers in the blanks.

______a. If a contractor paid an electrician $150.00, which is 87 percent of his salary, how much more money would the electrician have coming?

______b. If 12 percent of the fixtures for a job are stolen, how many fixtures will be left of the 2100 stored for the job?

______c. If an electrical contractor bought $24,000 worth of equipment and sold it for $30,000, what was her percentage of profit?

Written Test

21. Match terms used in geometry with their definitions. Write the correct numbers in the blanks.

______a. Volume of an object that is 1 foot long, 1 foot wide, and 1 foot high

______b. Shape formed by straight or curved lines

______c. Line or surface at a right angle to another line or surface

______d. Outer limits or boundary

______e. Greek letter (π) representing the ratio of a circle's circumference to its diameter; ratio is approximately 3.1416

______f. Distance around the outer edge of a circle

______g. Distance between the outer edges of a circle through its center point

______h. Measure of a flat surface; expressed in square units

______i. Line from the center of a circle to any point on the edge of the circle

______j. Relating to, consisting of, or resembling a straight line

______k. Line or surface extending in the same direction an equal distance apart and never meeting

______l. Space occupied by a body; expressed in cubic units

______m. Angle formed by two lines perpendicular to each other; a 90-degree angle

______n. Unit with three equal dimensions, including length, width, and height

1. Perimeter
2. Radius
3. Volume
4. Lineal
5. Parallel
6. Diameter
7. Geometric figure
8. Area
9. Cubic foot
10. Circumference
11. Cubic unit
12. Right angle
13. Pi
14. Perpendicular

Written Test

22. Match types of geometric figures with their descriptions. Write the correct numbers in the blanks.

______a. Figure having three sides and three angles

______b. Figure having four sides of equal length and four right angles

______c. Flat, round figure formed by one curved line, all points of which are equidistant from center point

______d. Figure having no right angles and four sides of equal length

______e. Figure with only one pair of parallel opposite sides

______f. Figure with two parallel ends of equal length, two parallel sides of equal length, and four right angles

______g. Figure such as a square, rectangle, or rhombus with two parallel ends of equal length and two parallel sides of equal length

1. Circle
2. Parallelogram
3. Trapezoid
4. Triangle
5. Rectangle
6. Rhombus
7. Square

23. Match units of measure with their equivalents. Write the correct numbers in the blanks.

______a. Equal to five thousand, two hundred and eighty feet (5280′)

______b. Equal to one-twelfth of a foot ($\frac{1}{12}$′) or one thirty-sixth of a yard ($\frac{1}{36}$ yard)

______c. Equal to three feet (3′) or thirty-six inches (36″)

______d. Equal to $\frac{1}{360}$ of a circle

______e. Equal to sixteen and one-half feet (16½′)

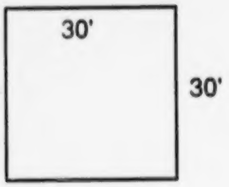
______f. Equal to twelve inches (12″) or one-third of a yard ($\frac{1}{3}$ yard)

1. Inch (″)
2. Foot (′)
3. Yard
4. Rod
5. Mile
6. Degree (°)

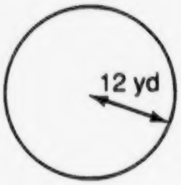
Written Test

24. Calculate the area of each of the following geometric figures. Show your work. Write the correct answers in the blanks.

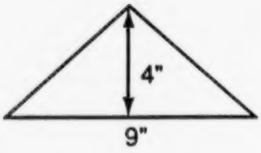
____________ a.



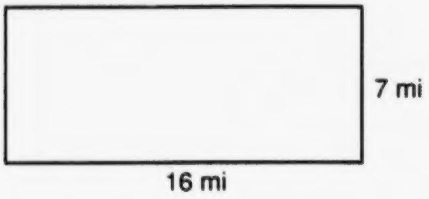
____________ b.



____________ c.

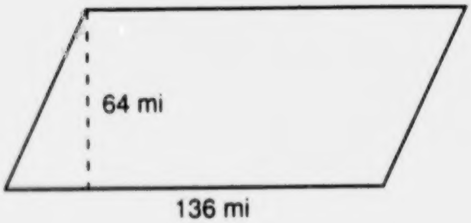


____________ d.

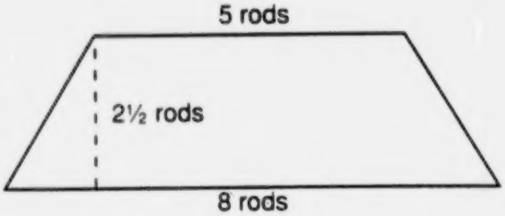


Written Test

_______________e.



_______________f.


5 rods
2½ rods
8 rods

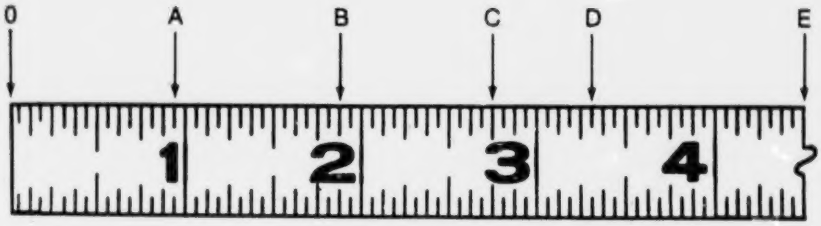
25. Match metric prefixes with their values. Write the correct numbers in the blanks.

______a.	100	1. kilo- (k)
______b.	1/1000	2. deka- (da)
______c.	1/100	3. hecto- (h)
______d.	1/10	4. centi- (c)
______e.	10	5. milli- (m)
______f.	1,000	6. deci- (d)

Written Test

26. Read the English and metric rules illustrated below. Write your answers on the blanks provided.

English rule (Read to the nearest sixteenth inch.)


0
A
B
C
D
E
1
2
3
4

a. 0 to A = ____________________

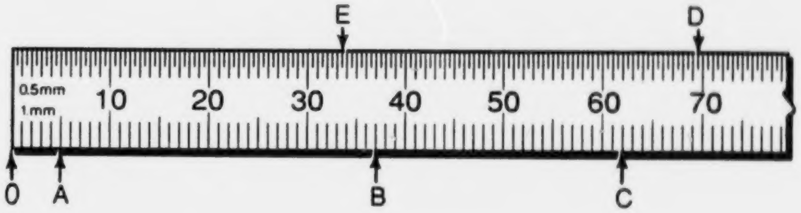
b. 0 to B = ____________________

c. 0 to C = ____________________

d. 0 to D = ____________________

e. 0 to E = ____________________

Metric rule (Read to the nearest 0.5 millimeter.)


E
D
0.5mm
1mm
10
20
30
40
50
60
70
0
A
B
C

a. 0 to A = ____________________

b. 0 to B = ____________________

c. 0 to C = ____________________

d. 0 to D = ____________________

e. 0 to E = ____________________ 1066

Related Math and Measuring
Unit 17

Unit Evaluation Form

Student Name ______________________________ Unit Rating __________

Assignment Sheet 1—Add Whole Numbers Rating _____

Comments: ____

____

Assignment Sheet 2—Subtract Whole Numbers Rating _____

Comments: ____

____

Assignment Sheet 3—Multiply Whole Numbers Rating _____

Comments: ____

____

Assignment Sheet 4—Divide Whole Numbers Rating _____

Comments: ____

____

Assignment Sheet 5—Reduce Fractions to Lowest Terms Rating _____

Comments: ____

____

Assignment Sheet 6—Convert Fractions and Mixed Numbers Rating _____

Comments: ____

____

Unit Evaluation Form

Assignment Sheet 7—Add Fractions Rating ______

Comments: ____

____

Assignment Sheet 8—Subtract Fractions Rating ______

Comments: ____

____

Assignment Sheet 9—Multiply Fractions Rating ______

Comments: ____

____

Assignment Sheet 10—Add Decimal Numbers Rating ______

Comments: ____

____

Assignment Sheet 11—Subtract Decimal Numbers Rating ______

Comments: ____

____

Assignment Sheet 12—Multiply Decimal Numbers Rating ______

Comments: ____

____

Assignment Sheet 13—Divide Decimal Numbers Rating ______

Comments: ____

____

Unit Evaluation Form

Assignment Sheet 14—Convert Fractions and Percentages Rating ______

Comments: ____

____

Assignment Sheet 15—Solve Percentage Problems Rating ______

Comments: ____

____

Assignment Sheet 16—Calculate Area of Geometric Figures Rating ______

Comments: ____

____

Written Test Scores

Pretest ______ Posttest ______ Other ______

Other ______ ____

____

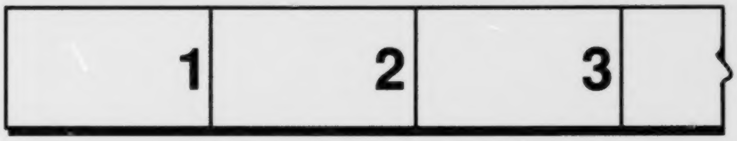
Teacher Signature ______________________________ Date ____________

Student Signature ______________________________ Date ____________

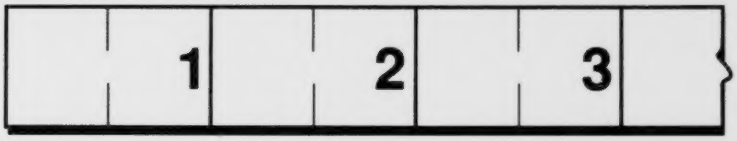
***Permission to duplicate this form is granted.**

Graduations on a Rule

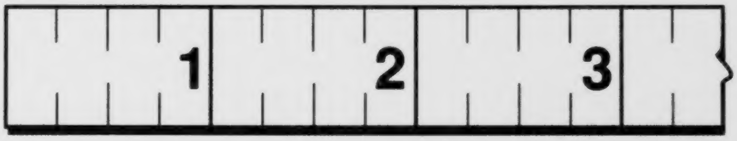
Inches



Halves



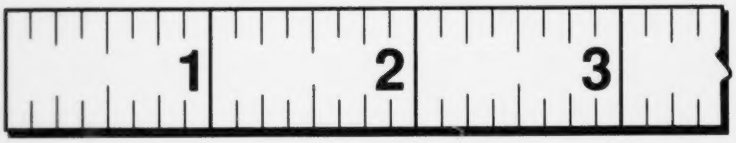
Quarters or Fourths



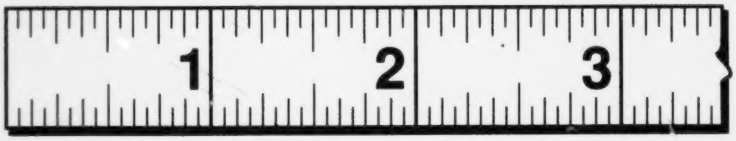
1070

Graduations on a Rule
(Continued)

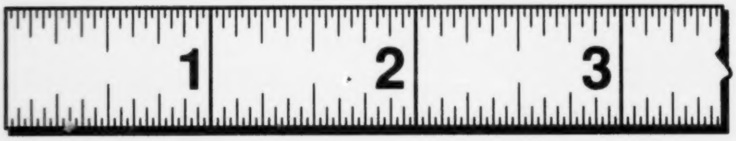
Eighths



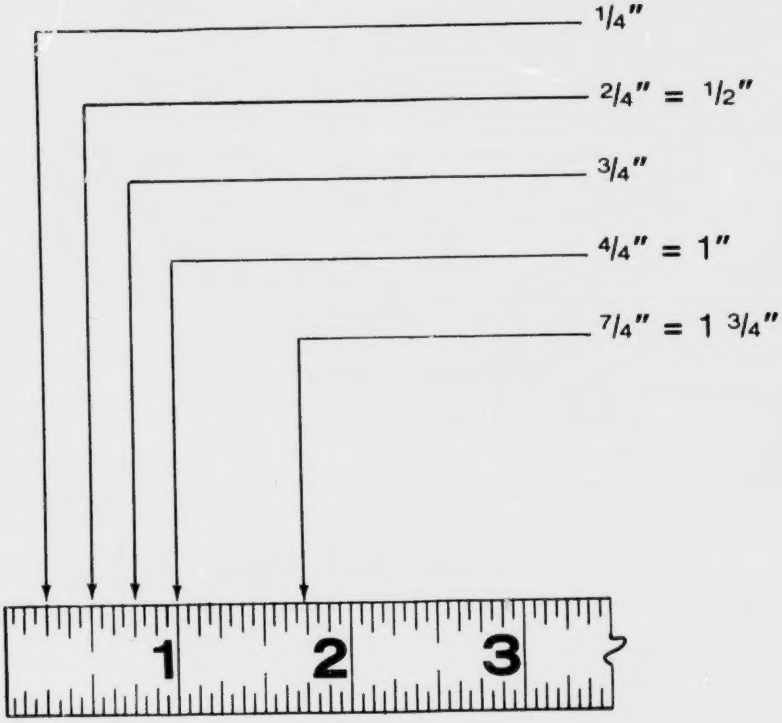
Sixteenths



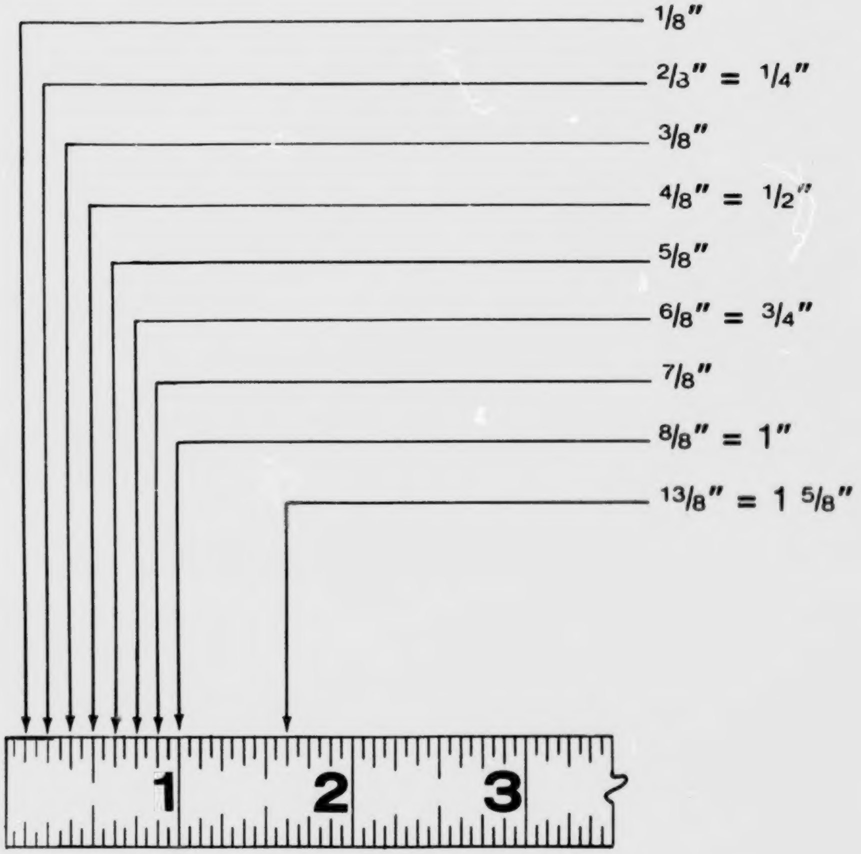
Thirty-Seconds



Reading Fourths on a Rule

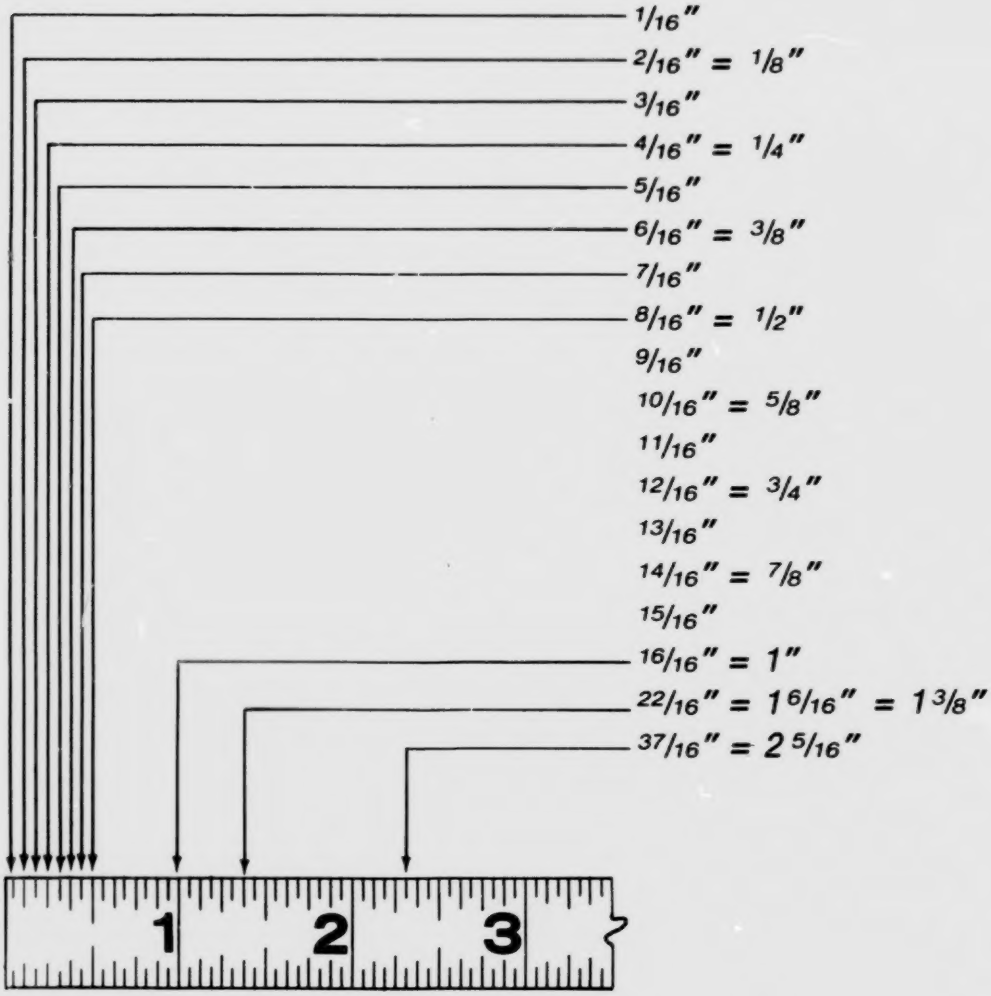

1/4"
2/4" = 1/2"
3/4"
4/4" = 1"
7/4" = 1 3/4"
1
2
3

Reading Eighths on a Rule

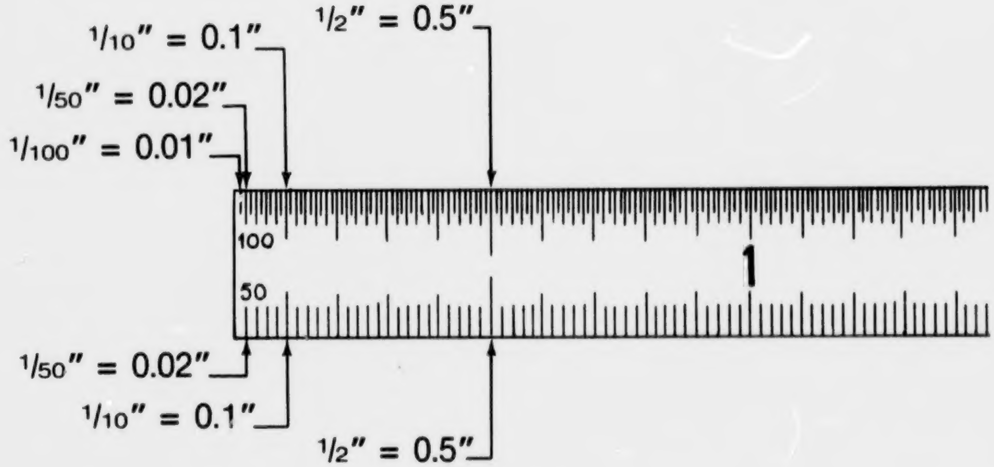

1/8"
2/3" = 1/4"
3/8"
4/8" = 1/2"
5/8"
6/8" = 3/4"
7/8"
8/8" = 1"
13/8" = 1 5/8"
1
2
3

1073

Reading Sixteenths on a Rule


1/16"
2/16" = 1/8"
3/16"
4/16" = 1/4"
5/16"
6/16" = 3/8"
7/16"
8/16" = 1/2"
9/16"
10/16" = 5/8"
11/16"
12/16" = 3/4"
13/16"
14/16" = 7/8"
15/16"
16/16" = 1"
22/16" = 1 6/16" = 1 3/8"
37/16" = 2 5/16"
1
2
3

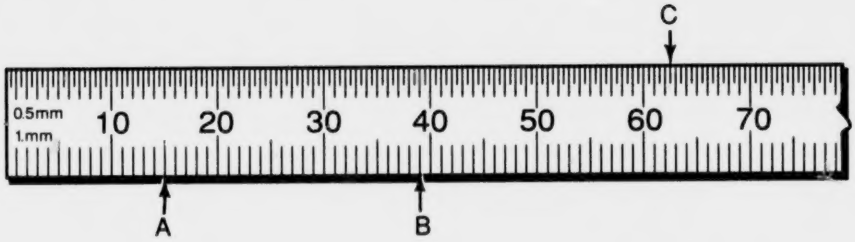
Reading Decimal Inches


1/10" = 0.1"
1/2" = 0.5"
1/50" = 0.02"
1/100" = 0.01"
100
50
1
1/50" = 0.02"
1/10" = 0.1"
1/2" = 0.5"

English rule with decimal graduations in fiftieths and one hundredths

1075

Reading Measurements on a Metric Rule



Metric rule with 1-mm and 0.5-mm graduations

1. Read the measurement to reference point A.

   The measurement to reference point A is 10 mm plus 5 mm.

   A = 10 mm + 5 mm = 15 mm

2. Read the measurement to reference point B.

   The measurement to reference point B is 1 mm less than 40 mm.

   B = 40 mm − 1 mm = 39 mm

3. Read the measurement to reference point C.

   The measurement to reference point C is 60 mm plus two 1-mm graduations plus one 0.5-mm graduation.

   C = 60 mm + 2 mm + 0.5 mm = 62.5 mm

Related Math and Measuring
Unit 17

Information Sheet

1. **Terms and definitions associated with math and measuring**

   a. **Whole number (integer)** — Any of the natural numbers, both positive and negative, that represents a complete item

   Example: 25 is a whole number as opposed to ¾, a fraction or part of a whole.

   b. **Digit** — Any one of the ten symbols, 0 to 9, by which all numbers can be expressed

   c. **Fraction** — Part of a whole; represents one or more equal parts of a unit (Figures 1 and 2)

   Examples:

   Figure 1

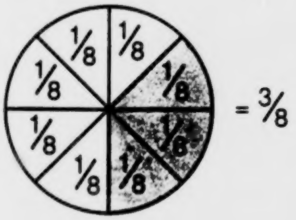
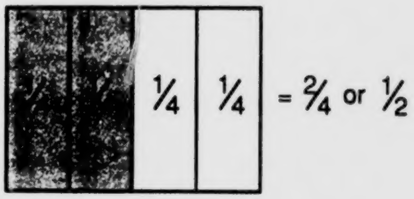


   Figure 2



   d. **Decimal** — Fraction with an unwritten denominator of 10 or some power of 10; indicated with a point before the number

   Examples: $0.1 = \frac{1}{10}$ $0.06 = \frac{6}{100}$ $0.003 = \frac{3}{1000}$

   e. **Addition** — Process of totaling two or more numbers to find another number called a sum

   Example: 3 + 5 + 9 = 17

   f. **Subtraction** — Opposite operation of addition

   Example: 8 − 4 = 4 as opposed to 4 + 4 = 8

g. **Multiplication** — Abbreviated process of adding a number to itself a specified number of times

Example: $6 \times 3 = 18$ as opposed to $6 + 6 + 6 = 18$

h. **Division** — Opposite operation of multiplication

Example: $16 + 2 = 8$ as opposed to $8 \times 2 = 16$

i. **Percent** — One part in a hundred; reckoned on the basis of a whole divided into one hundred parts

j. **Ratio** — Relationship in quantity, amount, or size between two or more things

k. **Proportional** — Being relatively equal in size or quantity

Example: $1:1:3 = 0.5:0.5:1.5$

l. **Meter** — Metric unit used to measure length

m. **Liter** — Metric unit used to measure capacity

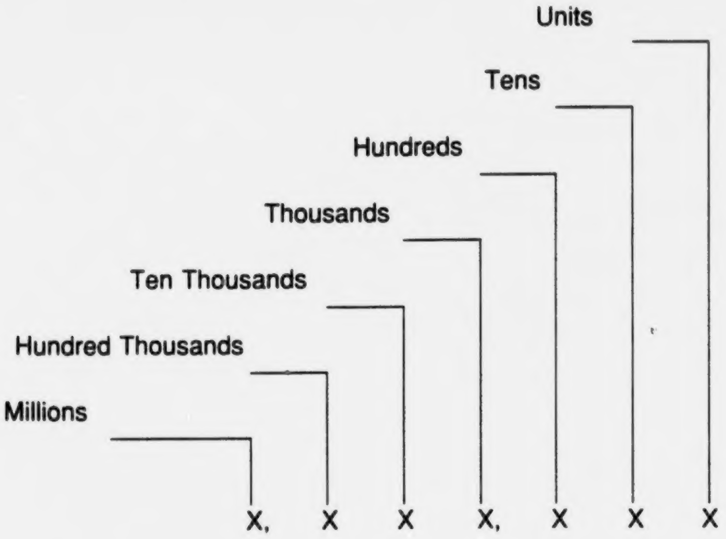
2. **Interpretations of symbols used in math problems**

Plus sign (addition)	+
Minus sign (subtraction)	−
Times sign (multiplication)	×
Division sign	+
Division frame	⟌
Equal sign	=
Decimal point	.
Percent symbol	%
Ratio symbol	:
Pi sign	π

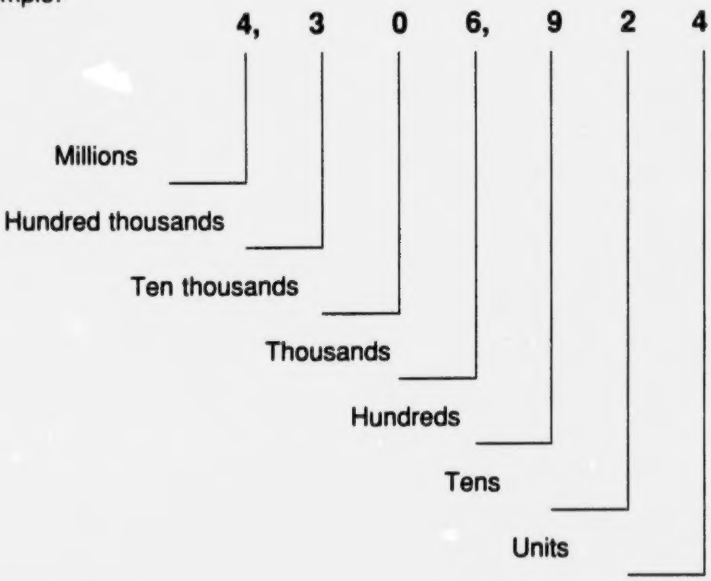
Information Sheet

3. Place values of a whole number

Note: The position of a digit in a number shows how much that digit is worth. These positions are called *place values.*


Units
Tens
Hundreds
Thousands
Ten Thousands
Hundred Thousands
Millions
X, X X X, X X X

Example:


4, 3 0 6, 9 2 4
Millions
Hundred thousands
Ten thousands
Thousands
Hundreds
Tens
Units

Note: The number in this example is four million, three hundred six thousand, nine hundred twenty-four.

Information Sheet

4. Adding whole numbers

a. Set up problem by writing units under units, tens under tens, and so on.

Example: Add the whole numbers 1632, 17, 550.

$$\begin{array}{r}1632\\17\\\underline{+\ \ 550}\end{array}$$

b. Add each column separately, beginning at top of units column.

Example:

$$\begin{array}{r}1632\\17\\+\ \ 550\\\hline 9\end{array}\qquad\begin{array}{r}1632\\17\\+\ \ 550\\\hline 99\end{array}$$

c. If the sum of any column is two or more digits, write the units digit in your answer and carry the remaining digit(s) to the top of next column to the left.

Example:

$$\begin{array}{rr}&\\&1632\\&17\\\text{Write units}&+\ \ 550\\\text{digit.}&\rightarrow 199\end{array}\qquad\begin{array}{rl}1\ \leftarrow&\text{Carry remaining}\\1632&\quad\text{digit.}\\17&\\+\ \ 550&\\\hline 199&\end{array}$$

d. Add any carried digit(s) above the column with that column.

Example:

$$\begin{array}{rl}1\ \ \ \ &\text{Carried Digit}\\1632&\\17&\\+\ \ 550&\\\hline 2199&\end{array}$$

5. Subtracting whole numbers

a. Set up problem by writing units under units, tens under tens, and so on.

Note: The top number in the problem (original number) is almost always larger than the bottom number (subtracted number).

Example: Subtract 91 from 123.

$$\begin{array}{rl}123&\text{Original Number}\\\underline{-\ \ 91}&\text{Subtracted Number}\end{array}$$

Information Sheet

b. Subtract each column separately, beginning at bottom of units column.

Example:
$$\begin{array}{r} 123 \\ \underline{-\ \ 91}\uparrow \\ 2 \end{array}$$

c. If a digit in the subtracted number is larger than the digit above it, "borrow" 1 from the top digit in the next column to the left, decreasing that digit by one and increasing the digit being subtracted by ten.

Example:
$$\begin{array}{r} 123 \\ \underline{-\ \ 91} \\ 32 \end{array}$$

d. If there is nothing to borrow in the next left column (column contains a zero), first borrow for that column from its next left column.

Example:
$$\begin{array}{rrrr} 906 & 906 & 906 & 906 \\ \underline{-318} & \underline{-318} & \underline{-318} & \underline{-318} \\ & 8 & 88 & 588 \end{array}$$

e. Check your subtraction by adding your answer to the subtracted number.

Example:

	Problem		Check
271	Original Number	271	Original Number
− 164↑	Subtracted Number	− 164	
107	Answer	+ 107	
		271	Check Answer

Note: If you have solved the problem correctly, your check answer should be the same as the original number.

6. Multiplying whole numbers

a. Set up problem by writing the larger number (original number) above the smaller number (multiplier), writing units under units, tens under tens, and so on.

Note: You will get the correct answer (product) no matter which number is placed above the other, but the faster method places the larger above the smaller.

Example: Multiply the numbers 53 and 4.

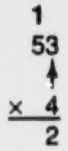
53	Orignial Number
× 4	Multiplier

Information Sheet

b. If the multiplier contains only one digit, multiply each digit in the original number by it, working from right to left.

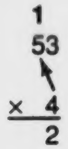
- Multiply units digit in original number by multiplier.
- Write answer units digit and insert necessary carry digit above next left column in original number as required.

Example:



- Multiply tens digit by multiplier and add carried digit as required.

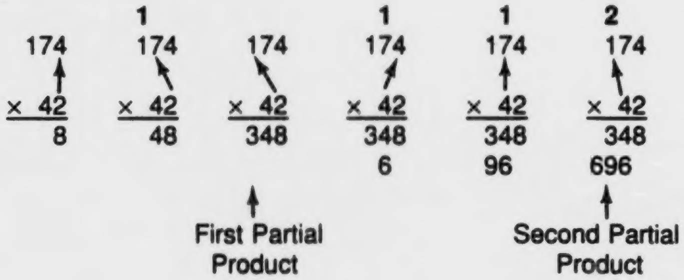
Example:



c. If the multiplier contains more than one digit, find partial products.

- Multiply each digit in original number by each digit in multiplier, moving from right to left.
- Align partial products so that right-hand digit of each is directly under its corresponding digit in the multiplier.

Example: Multiply the numbers 174 and 42


174
× 42
8
1
174
× 42
48
174
× 42
348
First Partial Product
1
174
× 42
348
6
1
174
× 42
348
96
2
174
× 42
348
696
Second Partial Product

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d. Add the partial products.

Example: $\begin{array}{r} 174 \\ \underline{\times\ \ 42} \\ 348 \\ \underline{+\ 696} \\ 7308 \end{array}$ Answer (Product)

7. Dividing whole numbers

a. Set up problem by writing original number (number to be divided) inside a division frame, and by writing divisor (number you are dividing by) outside frame.

Example: How many times will 33 go into 3347?

Divisor $33\overline{)3347}$ Original Number

b. Determine how many times the divisor will go into the first digit of the original number. If it will not, write a zero in the answer space directly above the first digit. Then determine how many times the divisor will go into the first two numbers of the original number.

Note: Continue trying to divide the original number by the divisor until a set of digits can be divided. Remember to write a zero each time the set of digits cannot be divided.

Example: $\begin{array}{l} \ \ \ \ 0 \\ 34\overline{)3347} \end{array}$ 34 goes into 3 zero times.

$\begin{array}{l} \ \ \ \ 00 \\ 34\overline{)3347} \end{array}$ 34 goes into 33 zero times.

$\begin{array}{l} \ \ \ \ 009 \\ 34\overline{)3347} \end{array}$ 34 goes into 334 nine times.

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c. Multiply the divisor by the answer (digit above frame); write this answer under the digit(s) that divisor went into, and subtract.

Example:

$$\begin{array}{r} 34 \\ \underline{\times \;\; 9} \\ 306 \end{array}$$

Multiply divisor (34) by answer (9).

$$\begin{array}{r} 009 \\ 34\overline{)3347} \\ -\underline{306} \\ 28 \end{array}$$

Write answer under 334, the digits divisor went into, and subtract.

d. Bring down next unused digit from original number, and place it to the right of the subtracted difference (remainder)—even if the remainder is zero.

Example:

$$\begin{array}{r} 009 \\ 34\overline{)3347} \\ \underline{306\downarrow} \\ 287 \end{array}$$

e. Determine how many times the divisor will go into this new number; write your answer in the answer space above the digit that was brought down.

Example:

$$\begin{array}{r} 0098 \\ 34\overline{)3347} \\ \underline{306} \\ 287 \end{array}$$

f. Multiply the divisor by the last digit you wrote in the answer; write this product under the digits that divisor went into, and subtract.

Example:

$$\begin{array}{r} 34 \\ \underline{\times \;\; 8} \\ 272 \end{array}$$

Multiply divisor (34) by answer (8).

$$\begin{array}{r} 0098 \\ 34\overline{)3347} \\ \underline{306} \\ 287 \\ -\;\underline{272} \\ 15 \end{array}$$

Write product under 287, the digits that divisor went into, and subtract.

g. Continue this process until all numbers in the original number are used.

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h. Write any remaining subtracted difference as a remainder.

Example:

$$\begin{array}{rl}
0098 & \\
34\overline{)3347} & \\
\underline{306} & \\
287 & \\
\underline{272} & \\
15 & \text{Remainder}
\end{array}$$

i. Check your answer by multiplying your answer times the divisor and adding the remainder to this number.

Note: If you have solved the problem correctly, your check answer should be the same as your original number.

Example:

$$\begin{array}{rl}
98 & \text{Answer}\\
\underline{\times\ 34} & \text{Divisor}\\
392 & \\
\underline{294} & \\
3332 & \\
\underline{+\ 15} & \text{Remainder}\\
3347 & \text{Check Answer (Same as Original Number)}
\end{array}$$

8. Distinguishing among types of fractions

a. **Proper** — Top number of fraction (numerator) is smaller than bottom number of fraction (denominator).

Example: $\dfrac{7}{8}\ \begin{matrix}\text{Numerator}\\ \text{Denominator}\end{matrix}$

b. **Improper** — Top number of fraction (numerator) is larger than bottom number of fraction (denominator).

Examples: $\dfrac{9}{8}\quad \dfrac{16}{16}$

c. **Mixed numbers** — Contain a whole number and a proper fraction.

Examples: $9\frac{1}{2}$, $1\frac{7}{8}$, $4\frac{3}{4}$

Information Sheet

9. **Reducing fractions to lowest terms**—Divide the numerator and denominator by the largest whole number that will go into each evenly.

Example: Reduce $\frac{4}{16}$ to its lowest terms.

$$\frac{4}{16} = \frac{4 + 4}{16 + 4} = \frac{1}{4}$$

Note: The fraction $\frac{1}{4}$ is reduced to its lowest term because the numerator (1) and the denominator (4) cannot be divided by the same number.

10. **Converting mixed numbers and improper fractions**

a. Converting mixed numbers to improper fractions

- Multiply the whole number by the denominator of the fraction.

  Example: Convert $4\frac{3}{8}$ to an improper fraction.

  $8 \times 4 = 32$

- Add your answer to the numerator.

  Example: $32 + 3 = 35$

- Place this sum over the original denominator.

  Example: $\frac{35}{8}$ Improper Fraction

b. Converting improper fractions to mixed numbers

- Divide the numerator by the denominator.

  Example: Convert $\frac{18}{15}$ to a mixed number.

$$\begin{array}{r} 01 \\ 15\overline{)18} \\ \underline{15} \\ 3 \end{array} \quad \text{Remainder}$$

- Place the remainder over the denominator.

  Example: $\frac{3}{15}$ Remainder Denominator

Information Sheet

- Reduce this fraction if necessary.

  Example: $\frac{3}{15} = \frac{3 \div 3}{15 \div 3} = \frac{1}{5}$

- Add the reduced fraction to the whole number obtained by dividing the numerator by the denominator.

  Example: $1 + \frac{1}{5} = 1\frac{1}{5}$ Mixed Number

11. Adding fractions

a. Like fractions

Note: Like fractions are those having the same, or common, denominators.

Examples: ¼ and ¾, ⅝ and ⅝, and 1/16 and 3/16

- Add the numerators.
- Place sum of numerators over common denominator.
- Convert to mixed numbers and reduce as required.

Example 1: Add ¼ and ¾.

$$\frac{1}{4} + \frac{2}{4} = \frac{1+2}{4} = \frac{3}{4}$$

Example 2: Add ⅝ and ⅝.

$$\frac{5}{8} + \frac{5}{8} = \frac{5+5}{8} = \frac{10}{8} = 10 \div 8 = 1\frac{2}{8} = 1\frac{1}{4}$$

Example 3: Add 1/16 and 3/16.

$$\frac{1}{16} + \frac{3}{16} = \frac{1+3}{16} = \frac{4}{16} = \frac{4 \div 4}{16 \div 4} = \frac{1}{4}$$

Information Sheet

b. Unlike fractions

Examples: $\frac{11}{12}$ and $\frac{3}{9}$, $\frac{1}{8}$ and $\frac{3}{4}$

- Change to like fractions.
    - — Find the lowest number into which each denominator can be divided evenly (lowest common denominator).
    - — Multiply the numerators and denominators of each fraction by the number of times its denominator can be divided into the lowest common denominator.

Example 1: Add $\frac{11}{12}$ and $\frac{3}{9}$.

36 is lowest number into which both 12 and 9 can be divided evenly.

$36 \div 12 = 3$

$36 \div 9 = 4$

$$\frac{11}{12} = \frac{11 \times 3}{12 \times 3} = \frac{33}{36}$$

$$\frac{3}{9} = \frac{3 \times 4}{9 \times 4} = \frac{12}{36}$$

Example 2: Add $\frac{1}{8}$ and $\frac{3}{4}$.

8 is the lowest number into which both 8 and 4 can be divided evenly.

$8 \div 8 = 1$

$8 \div 4 = 2$

$\frac{1}{8}$ remains as $\frac{1}{8}$ because 8 is the common denominator.

$$\frac{3}{4} = \frac{3 \times 2}{4 \times 2} = \frac{6}{8}$$

Information Sheet

- Add like fractions and reduce or convert to mixed numbers as required.

Example 1: Add $\frac{11}{12}$ and $\frac{3}{9}$.

$$\frac{11}{12} = \frac{33}{36} \text{ and } \frac{3}{9} = \frac{12}{36}$$

$$\frac{33}{36} + \frac{12}{36} = \frac{33 + 12}{36} = \frac{45}{36} = \frac{5}{4} = 1\frac{1}{4}$$

Example 2: Add $\frac{1}{8}$ and $\frac{3}{4}$.

$$\frac{1}{8} \text{ remains } \frac{1}{8} \text{ and } \frac{3}{4} = \frac{6}{8}$$

$$\frac{1}{8} + \frac{6}{8} = \frac{1 + 6}{8} = \frac{7}{8}$$

c. Mixed numbers

- Add whole numbers.
- Add fractions, first finding common denominators if necessary, and reduce or convert to mixed numbers as necessary.
- Add the sums of steps 1 and 2.

Example 1: Add $3\frac{1}{8}$ and $7\frac{3}{8}$.

Add whole numbers: $3 + 7 = 10$

Add fractions and reduce: $\frac{1}{8} + \frac{3}{8} = \frac{1 + 3}{8} = \frac{4}{8} = \frac{1}{2}$

Add the sums of steps 1 and 2: $10 + \frac{1}{2} = 10\frac{1}{2}$

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Example 2: Add $4\frac{2}{3}$ and $1\frac{5}{6}$.

Add whole numbers: $4 + 1 = 5$

Find common denominator: $\frac{2}{3} + \frac{5}{6} = \frac{4}{6} + \frac{5}{6}$

Add fractions, convert to mixed number, and reduce: $\frac{4}{6} + \frac{5}{6} = \frac{9}{6} = 1\frac{3}{6} = 1\frac{1}{2}$

Add sums of steps 1 and 2: $5 + 1\frac{1}{2} = 6\frac{1}{2}$

12. Subtracting fractions

a. Like fractions

- Subtract smaller numerator from larger numerator.

  Example: Subtract $\frac{1}{16}$ from $\frac{7}{16}$.

  $7 - 1 = 6$

- Place subtraction answer over common denominator.

  Example: $\frac{6}{16}$

- Reduce to lowest terms as required.

  Example: $\frac{6}{16} = \frac{3}{8}$

b. Unlike fractions

- Change to like fractions.

  Example: Subtract $\frac{1}{2}$ from $\frac{3}{4}$.

  $\frac{3}{4}$ remains the same because 4 is the common denominator.

  $\frac{1}{2} = \frac{1 \times 2}{2 \times 2} = \frac{2}{4}$

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- Subtract as for like fractions.

  Example: $\frac{3}{4} - \frac{2}{4} = \frac{3-2}{4} = \frac{1}{4}$

- Reduce to lowest terms as required.

c. Mixed numbers

- Convert mixed numbers to like fractions.

  Example: Subtract 3½ from 5⅛

  $5\frac{1}{8} - 3\frac{1}{2} =$

  $5\frac{1}{8} - 3\frac{4}{8}$

- Borrow a one from the original whole number if needed, convert the one to a like fraction, and add it to the smaller fraction.

  Note: This step is needed only if the like fraction in the original number is smaller than the like fraction in the subtracted number.

  Example:
  $$5\frac{1}{8} - 3\frac{4}{8} = (4\frac{8}{8} + \frac{1}{8}) - 3\frac{4}{8}$$
  $$= 4\frac{9}{8} - 3\frac{4}{8}$$

- Subtract whole number from whole number and like fraction from like fraction.

  Example: $4\frac{9}{8} - 3\frac{4}{8} = 1\frac{5}{8}$

13. **Multiplying fractions**

a. Convert mixed numbers to improper fractions if necessary.

b. Multiply numerators by numerators and denominators by denominators.

c. Write the product of the numerators over the product of the denominators.

d. Convert improper fractions to mixed numbers and reduce as required.

Information Sheet

Example 1: Multiply ½ by ¾.

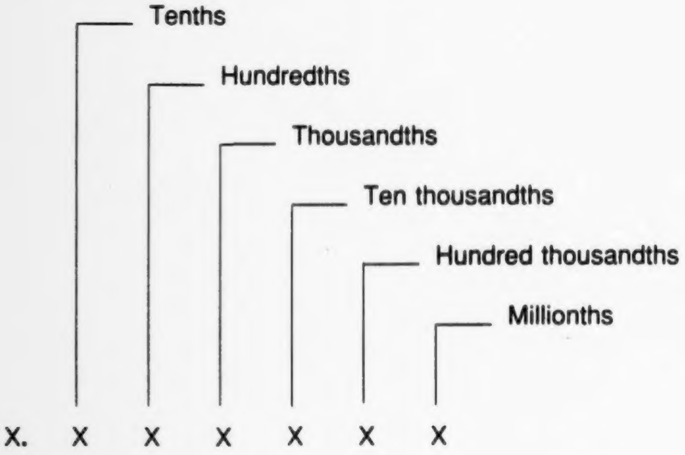
$$\frac{1}{2} \times \frac{3}{4} = \frac{1 \times 3}{2 \times 4} = \frac{3}{8}$$

Example 2: Multiply 1¼ by ½.

$$1\frac{1}{4} = \frac{5}{4} \quad \text{Convert to improper fraction.}$$

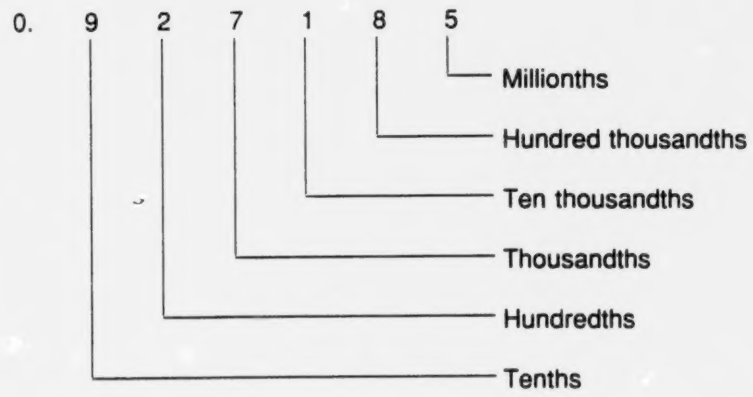
$$\frac{5}{4} \times \frac{1}{2} = \frac{5 \times 1}{4 \times 2} = \frac{5}{8}$$

14. **Place values of decimal numbers**


Tenths
Hundredths
Thousandths
Ten thousandths
Hundred thousandths
Millionths
X. X X X X X X

Information Sheet

Example:


0.
9
2
7
1
8
5
Millionths
Hundred thousandths
Ten thousandths
Thousandths
Hundredths
Tenths

Note: The number in the example is read as nine hundred twenty-seven thousand, one hundred eighty-five millionths.

15. Adding decimal numbers

a. Set up problem as for addition of whole numbers, aligning decimal points directly under each other.

Note: Zeros may be added to ensure that units line up under units, tens under tens, and so on. Whole numbers have an understood decimal point to the right of the units digit: 7 is 7., 75 is 75., and 754 is 754.

Example: Add 0.857, 2.1, 753, and 370.057.

0.857		000.857
2.1		002.100
753	or	753.000
+ 370.057		+ 370.057

b. Add each column of numbers as for whole numbers.

c. Locate the decimal point in the answer by placing it directly under the decimal points above.

Example:	000.857	
	002.100	
	753.000	
	+ 370.057	
	1126.014	Answer

Information Sheet

16. Subtracting decimal numbers

a. Set up problem as for subtraction of whole numbers, aligning decimal points directly under each other.

Example: Subtract 1.397 from 8.120.

8.120	Original Number
− 1.397	Subtracted Number

b. Subtract each column of numbers as for whole numbers.

c. Locate the decimal point in the answer by placing it directly under the decimal points above.

d. Check your subtraction by adding your answer to the subtracted number.

Note: If you have solved the problem correctly, your check answer should be the same as the original number.

Example:

8.120	Original Number
− 1.397	Subtracted Number
+ 6.723	Answer (Difference)
8.120	Check Answer

17. Multiplying decimal numbers

a. Set up problem and multiply as for multiplication of whole numbers.

Note: Do *not* align the decimal points in columns when setting up multiplication problems for decimal numbers.

Example: Multiply 27.935 by 7.07.

27. 935	Original Number
× 7. 07	Multiplier
195545	
1955450	
19750045	

Information Sheet

b. Add the number of decimal places to the right of the decimal points in the multiplier and original number.

Example:
$$\begin{array}{r} 27.935 \\ \underline{\times\ 7.07} \\ \end{array} \qquad \begin{array}{rl} 3 & \text{Decimal Places} \\ \underline{+2} & \text{Decimal Places} \\ 5 & \text{Total Decimal Places} \end{array}$$

c. Locate decimal point in answer by beginning at far right digit and counting off as many places to the left as the total decimal places found in step B.

Example:
$$\begin{array}{r} 27.935 \\ \times \quad 7.07 \\ \hline 195545 \\ 1955450 \\ \hline 197.50045 \end{array} \quad \text{5 Decimal Places}$$

18. Dividing decimal numbers

a. Set up problem as for division of whole numbers.

Example: Divide 0.25 by 0.005.

Divisor $0.005\overline{)0.25}$ Original Number

b. Move the decimal point in the divisor to the right of the far right digit in the divisor.

Example: $0.005.\overline{)0.25}$

c. Move the decimal point in the original number to the right by the same number of decimal places that you moved the decimal point in the divisor, adding zeros to the original number if necessary.

Example: $0.005.\overline{)0.250.}$

Note: If you are dividing a decimal number into a whole number, remember that whole numbers have an understood decimal point to the right of the units digit.

Example: $0.03\overline{)9}$ becomes $0.03.\overline{)9.00.}$

d. Place a decimal point in the answer space directly above the repositioned decimal point in the original number.

Example: $0.005.\overset{\hspace{2.4em}.}{\overline{)0.250.}}$

e. Divide as for whole numbers.

Example:

$$\begin{array}{r} 50. \\ 0005.\overline{)0250.} \\ \underline{025} \\ 00 \end{array}$$

f. Check your division by multiplying the original divisor (before decimal point was moved) by your answer and adding any remainder to this number.

Note: If you have solved the problem correctly, your check answer should be the same as the original number.

Example:	0.005	Divisor
	× 50	Answer
	0.250	Check Answer (Same as Original Number)

19. Converting fractions

a. Converting decimal fractions to common fractions

- Remove the decimal point.
- Place number over its respective denominator (10's, 100's, 1000's).
- Cancel zeros when possible.
- Reduce to lowest terms.

Example: Convert .25 to a common fraction

$$\begin{aligned} .25 &= 25 \\ &= \frac{25}{100} \\ &= \frac{1}{4} \end{aligned}$$

Information Sheet

Example: Convert .520 to a common fraction

$$.520 = 520 = \frac{520}{1000} = \frac{52}{100} = \frac{13}{25}$$

b. Converting common fractions to decimals and percentages

- Fractions to decimals — Divide the numerator by the denominator.

Example: Convert ⅝ to a decimal.

5 Numerator

8 Denominator

$$\begin{array}{r} 0.625 \\ 8\overline{)5.000} \\ \underline{4\,8} \\ 20 \\ \underline{16} \\ 40 \\ \underline{40} \\ 0 \end{array}$$

- Fractions to percentages

Note: Percent means that a number is a fraction of 100.

— Convert the fractions to decimals by dividing numerator by denominator.

— Move the decimal point in the answer two places to the right.

— Place the percent symbol after the number.

Example: Convert 7/33 to a percentage.

7 Numerator

33 Denominator

$$\begin{array}{r} 0.2121 = 21.21\% \\ 33\overline{)7.0000} \\ \underline{6\,6} \\ 40 \\ \underline{33} \\ 70 \\ \underline{66} \\ 40 \\ \underline{33} \\ 7 \end{array}$$

Information Sheet

c. Converting percentages to fractions and decimal numbers

- Percentages to fractions
    - Drop the percent symbol.
    - Place the number over 100.
    - Reduce to lowest terms if necessary.

Example: Convert 38% to a fraction.

$$38\% = 38 = \frac{38}{100} = \frac{19}{50}$$

- Percentages to decimals
    - Drop the percent symbol.
    - Move the decimal point two places to left.

Example: Convert 74% to a decimal.

$$74\% = 74 = 0.74$$

20. Solving percentage problems

Note: Percentage problems may involve solving for the percent ("16 is what percent of 80?"), the part ("What number is 20% of 80?"), or the whole ("16 is 20% of what number?").

a. Write the unknown as "X."

Note: The unknown may be the percent, the part, or the whole.

Example: 16 is what percent of 80?

16 is X percent of 80.

Information Sheet

b. Write the percent (known or unknown) as a fraction with a denominator of 100.

Example: 16 is $\frac{X}{100}$ percent of 80.

c. Write the part and the whole as a fraction, writing the part as the numerator and the whole as the denominator.

Example: $\frac{16}{80}$ Part
Whole

d. Set up the equation by writing the two fractions with an equal sign between them.

Example: $\frac{X}{100} = \frac{16}{80}$

e. Solve the equation by multiplying the numerator of each fraction by the denominator of the other.

Note: This process is known as *cross multiplying*.

Example:

$$\frac{X}{100} = \frac{16}{80}$$

$$80X = 1600$$

f. Divide each side of the equation by the multiplier of X.

Example: $80X = 1600$

$X = 20\%$

16 is 20% of 80.

21. **Terms used in geometry**

a. **Geometric figure** — Shape formed by straight or curved lines

b. **Perimeter** — Outer limits or boundary

c. **Lineal** — Relating to, consisting of, or resembling a straight line

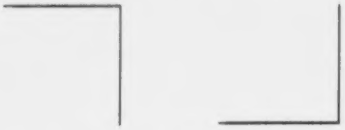
d. **Parallel** — Line or surface extending in the same direction an equal distance apart and never meeting

Example:

Information Sheet

e. **Right angle** — Angle formed by two lines perpendicular to each other; a 90 degree angle.

Examples:

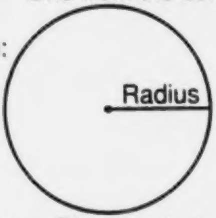


f. **Perpendicular** — Line or surface at right angle to another line or surface

Example:

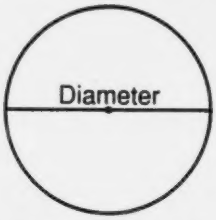
g. **Radius** — Line from the center of a circle to any point on the edge of the circle

Example:



h. **Diameter** — Distance between the outer edges of a circle through its center point

Example:



i. **Circumference** — Distance around the outer edge of a circle

j. **Pi** — Greek letter (π) representing the ratio of a circle's circumference to its diameter; ratio is approximately 3.1416

k. **Area** — Measure of a flat surface; expressed in square units

Example: W × L = Area in square units

l. **Volume** — Space occupied by a body; expressed in cubic units

m. **Cubic unit** — Unit with three equal dimensions including length, width, and height

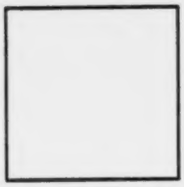
n. **Cubic foot** — Volume of an object that is 1 foot long, 1 foot wide, and 1 foot high

Information Sheet

22. Types of geometric figures

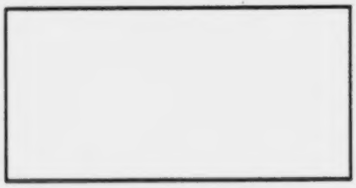
a. **Square** — Figure having four sides of equal length and four right angles

Example:



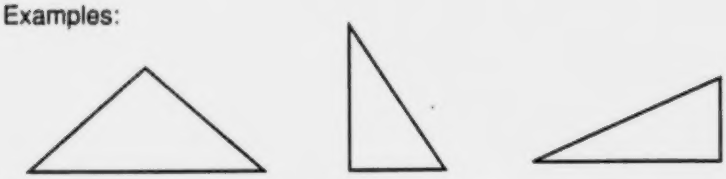
b. **Rectangle** — Figure with two parallel ends of equal length, two parallel sides of equal length, and four right angles

Example:



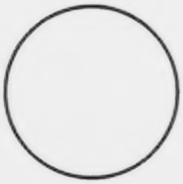
c. **Triangle** — Figure having three sides and three angles

Examples:



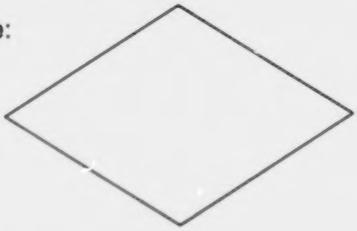
d. **Circle** — Flat, round figure formed by one curved line, all points of which are equidistant from center point

Example:



e. **Rhombus** — Figure having no right angles and four sides of equal length

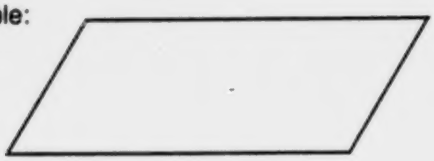
Example:



Information Sheet

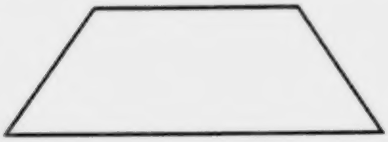
f. **Parallelogram** — Figure such as a square, rectangle, or rhombus with two parallel ends of equal length and two parallel sides of equal length

Example:



g. **Trapezoid** — Figure with only one pair of parallel opposite sides

Example:



23. Units of measure and their equivalents

a. **Inch (″)** — Equal to one-twelfth of a foot (1⁄12′) or one thirty-sixth of a yard (1⁄36 yard)

b. **Foot (′)** — Equal to twelve inches (12″) or one-third of a yard (1⁄3 yard)

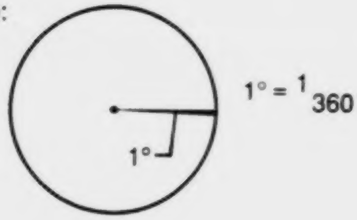
c. **Yard** — Equal to three feet (3′) or thirty-six inches (36″)

d. **Rod** — Equal to sixteen and one-half feet (16½′)

e. **Mile** — Equal to five thousand, two hundred and eighty feet (5280′)

f. **Degree (°)** — Equal to 1⁄360 of a circle

Example:



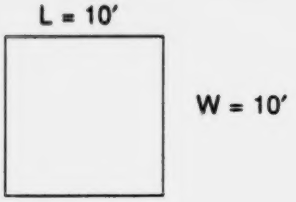
Information Sheet

24. Calculating area of geometric figures

Note: Area is always labeled in square units of measure.

a. **Square** — Use the formula Area = Length × Width or A = LW.

Example:



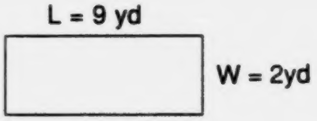
$A = LW$

$= 10 \times 10$

= 100 square feet

b. **Rectangle** — Use the formula Area = Length × Width or A = LW.

Example:



$A = LW$

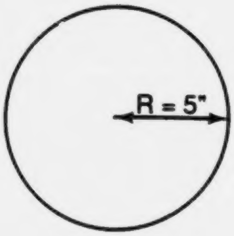
$= 9 \times 2$

= 18 square yards

c. **Circle** — Use the formula Area = πr^2 (radius × radius).

Note: Pi (π) is 3.14, which is the circumference of a circle divided by the diameter of the circle.

Example:



$A = \pi r^2$

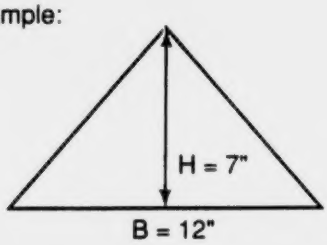
$= 3.14 \times (5 \times 5)$

= 78.50 square inches

Information Sheet

d. **Triangle** — Use the formula Area = ½ Base × Height, or A = ½ BH.

Example:



$$A = \frac{1}{2}BH$$

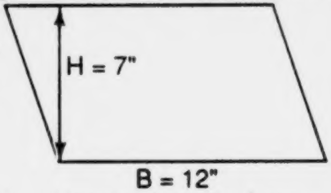
$$= (\frac{1}{2} \times 12) \times 7$$

$$= 6 \times 7$$

$$= 42 \text{ square inches}$$

e. **Parallelogram** — Use the formula Area = Base × Height, or A = BH.

Example:



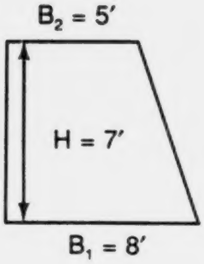
$$A = BH$$

$$= 12 \times 7$$

$$= 84 \text{ square inches}$$

f. **Trapezoid** — Use the formula Area = ½ $H(B_1 + B_2)$.

Example:



$$A = \frac{1}{2}H(B_1 + B_2)$$

$$= (\frac{1}{2} \times 7) \times (8 + 5)$$

$$= \frac{7}{2} \times 13$$

$$= \frac{7}{2} \times \frac{13}{1}$$

$$= \frac{91}{2}$$

$$= 45\frac{1}{2} \text{ square feet}$$

Information Sheet

25. Values of prefixes associated with metric measurement

Note: The basic units of measurement in the metric system are the meter (length), liter (capacity), and gram (mass or weight). Other units are named by adding the following prefixes to *meter, liter,* or *gram.* Since all measurement units in the metric system are powers of 10, metric prefixes make measurements easily understood. A millimeter, for instance, is one thousandth of a meter.

	Prefix	Value
a.	kilo- (k)	one thousand (1000)
b.	hecto- (h)	one hundred (100)
c.	deka- (da)	ten (10)
d.	deci- (d)	one tenth ($\frac{1}{10}$)
e.	centi- (c)	one hundredth ($\frac{1}{100}$)
f.	milli- (m)	one thousandth ($\frac{1}{1000}$)

Related Math and Measuring
Unit 17

Assignment Sheet 1—Add Whole Numbers

Name ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
Completed all problems and showed work	______
Labeled answers with correct unit of measurement	______
Computed a minimum of 18 of the 20 answers correctly per Assignment Sheet 1 answers	______

Directions: Solve the following addition problems.

Examples:

$$\begin{array}{r} 5 \\ \underline{+\,10} \\ 15 \end{array} \qquad \begin{array}{rl} \mathbf{1} & \leftarrow \text{Carried Digit} \\ 67 & \\ \underline{+\,25} & \\ 92 & \end{array} \qquad \begin{array}{rl} \mathbf{11} & \leftarrow \text{Carried Digits} \\ 539 & \\ 333 & \\ \underline{+\;\;432} & \\ 1304 & \end{array}$$

A. Solve each of the following addition problems. Show your work.

1. $\begin{array}{r} 2 \\ \underline{+\,9} \end{array}$ 2. $\begin{array}{r} 8 \\ \underline{+\,8} \end{array}$ 3. $\begin{array}{r} 7 \\ \underline{+\,6} \end{array}$ 4. $\begin{array}{r} 15 \\ \underline{+\,8} \end{array}$ 5. $\begin{array}{r} 81 \\ \underline{+\,27} \end{array}$

6. $\begin{array}{r} 7 \\ 38 \\ \underline{+\,43} \end{array}$ 7. $\begin{array}{r} 55 \\ 88 \\ \underline{+\,99} \end{array}$ 8. $\begin{array}{r} 341 \\ 428 \\ \underline{+\,769} \end{array}$ 9. $\begin{array}{r} 472 \\ 564 \\ \underline{+\,881} \end{array}$ 10. $\begin{array}{r} 9876 \\ 5432 \\ \underline{+\,1122} \end{array}$

B. Solve the following word problems. Show your work in the spaces provided. Write your answers on the blanks.

1. The wiring specialist has 12 receptacles. He has ordered and received 8 additional receptacles. How many total receptacles does he have?

   Total receptacles = ____________

Assignment Sheet 1

2. A fixture has a 34-candlepower bulb, a 26-candlepower bulb, a 9-candlepower bulb, and a 15-candlepower bulb. Find the total candlepower.

   Total candlepower = ____________

3. Tonja ordered the following number of fasteners on different dates: 256, 62, 575, and 242. How many fasteners should she be billed for?

   Number of fasteners = ____________

4. If an electrical technician paid $480 for a lighting fixture, $13 for conduit, $81 for tools and equipment, and $35 for supplies, what was the total cost?

   Total cost = ____________

5. On a major electrical installation, Bill worked 28 hours, Eliot worked 16 hours, and Shanedra worked 42 hours. What are the total hours worked on this job?

   Total hours worked = ____________

Assignment Sheet 1

6. In a toolbox are 23 socket wrenches, 14 open-end wrenches, 11 tubing wrenches, and 5 channel-lock wrenches. How many wrenches are in the toolbox?

   Number of wrenches in toolbox = ____________

7. There are 13 large boxes in the tool room, 7 medium boxes, and 11 small boxes. How many boxes are in the tool room?

   Number of boxes = ____________

8. Six installations were completed by electricians. The number of feet of conductors used is 65, 75, 69, 81, 57, and 76. What is the total number of feet used?

   Total number of feet = ____________

9. An electrician installs some outdoor antenna wiring measuring 40 feet, 60 feet, 37 feet, and 145 feet. How many feet of wiring were installed?

   Total number of feet = ____________

Assignment Sheet 1

10. Conductor in a circuit measures 18 inches, 25 inches, 19 inches, and 46 inches. What is the total length of conductor in the circuit (in inches)?

    Total number of inches = ____________

BW-669

Related Math and Measuring
Unit 17

Assignment Sheet 2—Subtract Whole Numbers

Name ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
Completed all problems and showed work	_____
Labeled answers with correct unit of measurement	_____
Computed a minimum of 20 of the 24 answers correctly per Assignment Sheet 2 answers	_____

Directions: Solve the following subtraction problems.

Examples:				
	12	Original Number	57	Original Number
	− 7	Subtracted Number	− 35	Subtracted Number
	+ 5	Answer (Difference)	+ 22	Answer (Difference)
	12	Check Answer (Same as Original Number)	57	Check Answer

A. Solve each of the following subtraction problems. Check your answer by adding the difference to the subtracted number. Show your work.

1. 9	2. 15	3. 75	4. 453	5. 742
− 5	− 8	− 22	− 47	− 318
6. 981	7. 1420	8. 3459	9. 55722	10. 98679
− 698	− 245	−1649	− 4272	− 8957

Assignment Sheet 2

B. Solve the following word problems. Show your work in the spaces provided. Write your answers on the blanks. Check your answers by adding the difference to the subtracted number.

1. If a shop needs 172 drop cloths and it has 46, how many more drop cloths would the shop need?

   Number of drop cloths needed = ____________

2. If there are 18 octagon boxes on inventory and you use 6 of them, how many are left?

   Number of octagon boxes left = ____________

3. Angela worked 33 hours on 2 major installations, and Henry worked 56 hours on similar installations. How many more hours did Henry work than Angela?

   Difference in hours worked = ____________

4. In the first year of operation, an electrical shop handled 1219 jobs. During the second year, the jobs increased to 2167. How many more jobs did the shop do the second year?

   Difference in jobs = ____________

Assignment Sheet 2

5. To install an overhead fixture takes 65 minutes. If you have already worked 27 minutes, how much longer will you need to work?

   Difference in minutes worked = ____________

6. Mr. Perez, the instructor, has 240 bar hangers in stock. If 98 are needed during the first semester course, how many are left for the second semester?

   Number of bar hangers left = ____________

7. If the average length of conduit used in a week is 2100 inches and you used 2310 inches, how much above average is the length of conduit you used?

   Inches used above average length = ____________

8. You can work only 13 hours this week. The following week you can work 6 hours. How much additional time will it take the third week if the job will take 27 total hours?

   Additional hours required = ____________

Assignment Sheet 2

9. The transportation pool uses 250 liters of oil per semester. There are only 127 liters of oil in the storage room. How many more liters will be needed for the semester?

Liters needed = ____________

10. Determine the number of kilometers traveled for each of five weeks from the odometer readings below.

Week	1	2	3	4	5
Reading (start)	32,119	32,899	33,988	35,976	37,065
Reading (end)	32,899	33,988	35,976	37,065	39,001

Week 1 __________________ km

Week 2 __________________ km

Week 3 __________________ km

Week 4 __________________ km

Week 5 __________________ km

Related Math and Measuring
Unit 17

Assignment Sheet 3—Multiply Whole Numbers

Name ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
Completed all problems and showed work	______
Labeled answers with correct unit of measurement	______
Computed a minimum of 18 of the 20 answers correctly per Assignment Sheet 3 answers	______

Directions: Solve the following multiplication problems.

Examples:

```
                   1 ← Carried Digit        11 ← Carried Digits
    8             53                       756
  × 7           ×  4                     × 312
   56            212                      1512 ← First Partial Product
                                          756  ← Second Partial Product
                                         2268  ← Third Partial Product
                                        235872 ← Product
```

A. Solve each of the following multiplication problems. Show your work.

```
1.   6     2.   9     3.  54     4.  721     5.  1682
   × 7        × 8       ×  6       ×   4       ×    5

6.  78     7.  453    8.  314    9.  2143   10.  4123
  × 26       ×  47      × 527      ×  235       × 1324
```

Assignment Sheet 3

B. Solve the following word problems. Show your work in the spaces provided. Write your answers on the blanks.

1. There are 4 conductors in a duct. How many conductors are in 8 ducts?

   Number of conductors = ____________

2. There are 24 metallic boxes in a case. How many boxes are in 4 cases?

   Number of boxes = ____________

3. There are 500 dry-wall screws in a box. How many are in 6 boxes?

   Number of screws = ____________

4. If it takes 4 new faceplates per installation, how many faceplates will be needed for 6 installations?

   Faceplates needed = ____________

Assignment Sheet 3

5. There are 16 electrical wiring students working on installations. If each student works 8 hours, what are the total hours spent?

   Total hours spent = ____________

6. If a can of lubricant costs $6 per pound, how much will 58 pounds cost?

   Total cost of lubricant = ____________

7. It takes 35 minutes to complete an installation. How much time does it will take to complete 9 installations of the same type?

   Total minutes required = ____________

8. How many of the school's cars can be washed in an automatic car wash in 9 hours if 15 can be washed in 1 hour?

   Total cars washed = ____________

Assignment Sheet 3

9. Figure the amount of time worked in 4 weeks by 12 electrical wiring specialists who work 30 hours each week.

   Hours worked = ____________

10. A truck travels 42 kilometers an hour for 6 hours daily for 19 days. Another truck travels 37 kilometers an hour for 6 hours daily for 23 days. A third truck travels 39 kilometers an hour for 6 hours daily for 22 days. What is the total kilometers of the three trucks?

    Total kilometers = ____________

Related Math and Measuring
Unit 17

Assignment Sheet 4—Divide Whole Numbers

Name ______________________________ Overall Rating __________

Evaluation criteria	Rating
Completed all problems and showed work	______
Labeled answers with correct unit of measurement	______
Computed a minimum of 14 of the 16 answers correctly per Assignment Sheet 4 answers	______

Directions: Solve the following division problems.

Examples:

```
          Answer
Divisor)Original Number                324
                                     3)972
                                       9
                                       7
                                       6
                                       12
                                       12

   0111 Answer          Check:          111 Answer
51)5678                              ×   51 Divisor
   51                                   111
    57                                 555
    51                                 5661
     68                              +   17 Remainder
     51                                5678 Original Number
     17 Remainder
```

Assignment Sheet 4

A. Solve each of the following division problems. Check your answers by multiplying the divisor by the original number. Show your work.

1. $2\overline{)8}$
2. $6\overline{)48}$
3. $9\overline{)819}$
4. $4\overline{)1248}$
5. $13\overline{)39}$
6. $66\overline{)198}$
7. $84\overline{)5212}$
8. $124\overline{)345}$
9. $464\overline{)829}$
10. $746\overline{)2872}$

B. Solve the following problems. Show your work in the spaces provided. Write your answer on the blanks.

1. If a can of dry-wall screws holds 5 pounds, how many cans can be filled from a 55-pound drum?

   Number of cans = ____________

Assignment Sheet 4

2. Clark received $418 for an installation. He worked 19 hours on the job. How much did he make per hour?

   Amount earned per hour = ____________

3. How many 4-screw boxes can be installed using a case containing 416 screws?

   Number of 4-screw boxes = ____________

4. If Vonda can install 4 GFCIs a day, how many days will it take her to install 92 GFCIs?

   Number of days = ____________

Assignment Sheet 4

5. New electrical measuring equipment cost $13,104. How much will the school's monthly payments be if the equipment is financed over a 14-month period?

Monthly payments = ____________

6. An electrican has 3,828 business cards. He gives away 116 each day. How many days' supply does he have?

Number of days = ____________

Related Math and Measuring
Unit 17

Assignment Sheet 5—Reduce Fractions to Lowest Terms

Name ______________________________ Overall Rating __________

Evaluation criteria	Rating
Completed all problems and showed work	_____
Labeled answers with correct unit of measurement	_____
Computed a minimum of 8 of the 10 answers correctly per Assignment Sheet 5 answers	_____

Directions: Reduce the following fractions to their lowest terms.

Examples: $\frac{9}{12} = \frac{9 \div 3}{12 \div 3} = \frac{3}{4}$ $\frac{12}{32} = \frac{12 \div 4}{32 \div 4} = \frac{3}{8}$

A. $\frac{4}{8}$ = __________

B. $\frac{8}{16}$ = __________

C. $\frac{2}{2}$ = __________

D. $\frac{4}{16}$ = __________

E. $\frac{12}{48}$ = __________

F. $\frac{9}{24}$ = __________

G. $\frac{16}{32}$ = __________

H. $\frac{2}{4}$ = __________

I. $\frac{9}{12}$ = __________

J. $\frac{50}{100}$ = __________

Related Math and Measuring
Unit 17

Assignment Sheet 6—Convert Fractions and Mixed Numbers

Name ____ Overall Rating __________

Evaluation criteria	**Rating**
Completed all problems and showed work	______
Labeled answers with correct unit of measurement	______
Computed a minimum of 30 of the 35 answers correctly per Assignment Sheet 6 answers	______

Directions: Convert the following fractions and mixed numbers. Reduce to lowest terms when possible.

A. Distinguish among the following fractions by writing a "P" in the blanks before a proper fraction, an "I" before an improper fraction, and an "M" in the blanks before a mixed number.

______1. $\frac{1}{2}$

______2. $3\frac{7}{8}$

______3. $\frac{16}{2}$

______4. $3\frac{1}{8}$

______5. $\frac{1}{4}$

______6. $\frac{1}{1}$

______7. $\frac{7}{2}$

______8. $8\frac{1}{2}$

______9. $\frac{4}{4}$

______10. $9\frac{3}{16}$

______11. $5\frac{1}{2}$

______12. $\frac{9}{8}$

______13. $\frac{9}{4}$

______14. $\frac{1}{8}$

______15. $16\frac{3}{4}$

Assignment Sheet 6

B. Convert each of the following mixed numbers to improper fractions. Reduce to lowest terms when possible.

1. $3\frac{1}{4}$ = ____________
2. $4\frac{1}{2}$ = ____________
3. $7\frac{3}{4}$ = ____________
4. $8\frac{1}{2}$ = ____________
5. $6\frac{1}{8}$ = ____________
6. $5\frac{2}{4}$ = ____________
7. $4\frac{1}{4}$ = ____________
8. $8\frac{1}{2}$ = ____________
9. $9\frac{1}{4}$ = ____________
10. $16\frac{1}{2}$ = ____________

C. Convert each of the following improper fractions to mixed numbers. Reduce to lowest terms when possible.

1. $\frac{7}{4}$ = ____________
2. $\frac{9}{2}$ = ____________
3. $\frac{6}{4}$ = ____________
4. $\frac{15}{8}$ = ____________
5. $\frac{19}{16}$ = ____________
6. $\frac{11}{8}$ = ____________
7. $\frac{75}{32}$ = ____________
8. $\frac{5}{2}$ = ____________
9. $\frac{15}{4}$ = ____________
10. $\frac{33}{16}$ = ____________

Related Math and Measuring
Unit 17

Assignment Sheet 7—Add Fractions

Name ______________________________ Overall Rating __________

Evaluation criteria	Rating
Completed all problems and showed work	______
Labeled answers with correct unit of measurement	______
Computed a minimum of 17 of the 19 answers correctly per Assignment Sheet 7 answers	______

Directions for adding like fractions:

Example: Add $\frac{3}{4}$ and $\frac{3}{4}$.

1. Add the numerators.

   Example: $3 + 3 = 6$

2. Place answer over common denominator and reduce to lowest terms if necessary.

   Example: $\frac{6}{4} = 1\frac{2}{4} = 1\frac{1}{2}$ Answer

Directions for adding unlike fractions:

Example: Add $\frac{1}{4} + \frac{7}{8}$.

1. Change to equivalent fractions with lowest common denominator.

   Example: $\frac{7}{8}$ remains the same, as 8 is lowest common denominator.

   $\frac{1}{4}$ is multiplied by $\frac{2}{2}$, or $\frac{1}{4} \times \frac{2}{2} = \frac{2}{8}$.

2. Add the new numerators.

   Example: $\frac{7 + 2}{8} = \frac{9}{8}$

Assignment Sheet 7

3. Change improper fraction to mixed number and reduce to lowest terms if necessary.

   Example: $\frac{9}{8} = 9 + 8 = 1\frac{1}{8}$ Answer

Directions for adding mixed numbers:

Example: Add $3\frac{5}{8} + 7\frac{5}{8}$.

1. Add numerators.

   Example: $\frac{5 + 5}{8} = \frac{10}{8}$

2. Change improper fraction to mixed number and reduce to lowest terms if necessary.

   Example: $\frac{10}{8} = 10 + 8 = 1\frac{2}{8} = 1\frac{1}{4}$

3. Add whole numbers and fractions.

   Example: $3 + 7 + 1 + \frac{1}{4} = 11\frac{1}{4}$ Answer

A. Add the following fractions. Show your work in the space provided below the problems. Reduce to lowest terms if necessary. Write your answers on the blanks beside the problems.

1. $\frac{7}{16} + \frac{5}{16} =$ ____________
2. $\frac{5}{8} + \frac{7}{8} =$ ____________
3. $\frac{1}{4} + \frac{2}{8} =$ ____________
4. $\frac{4}{16} + \frac{3}{4} =$ ____________
5. $\frac{9}{16} + \frac{5}{8} =$ ____________
6. $\frac{5}{8} + \frac{5}{32} =$ ____________
7. $\frac{3}{4} + \frac{5}{32} =$ ____________
8. $\frac{7}{8} + \frac{6}{16} =$ ____________
9. $\frac{9}{16} + \frac{3}{4} =$ ____________
10. $\frac{4}{4} + \frac{25}{32} =$ ____________

Assignment Sheet 7

B. Solve the following problems. Show your work in the spaces provided. Reduce to lowest terms if necessary. Write your answers on the blanks.

1. Add the lengths of two wires that are 6½ inches and 8¼ inches.

   Total length in inches = ____________

2. Carlos worked 4½ hours before lunch and 3¼ hours after lunch. How many hours did Carlos work?

   Total hours worked = ____________

3. Add the lengths of three extension tools that are 2⅛ inches, 3¼ inches, and 1¹³⁄₁₆ inches.

   Total length in inches = ____________

Assignment Sheet 7

4. Three pieces of conductor have lengths of $6\frac{5}{8}$ inches, $6\frac{3}{4}$ inches, and $6\frac{1}{4}$ inches. What is the total length of the three pieces of conductor?

   Total length in inches = ____________

5. In learning to read an English rule, Taro located $4\frac{7}{8}$ inches on the rule, Gustav read $3\frac{15}{16}$ inches, and Li-Chen located $4\frac{1}{4}$ inches. How many total inches were located?

   Total inches = ____________

6. Add three conductor segments $17\frac{15}{16}$ inches, $16\frac{3}{4}$ inches, and $25\frac{3}{8}$ inches.

   Combined segments in inches = ____________

Assignment Sheet 7

7. Three dimensions are $1\frac{11}{16}$ inches, $2\frac{3}{8}$ inches, and $2\frac{3}{4}$ inches. What is the combined dimension?

   Combined dimension in inches = ____________

8. A container of petroleum solvent has $1\frac{1}{2}$ liters in it. Sally adds $1\frac{3}{4}$ liters. How many liters are now in the container?

   Total liters of solvent = ____________

9. An electrician worked $5\frac{7}{8}$ hours, $3\frac{3}{4}$ hours, and $7\frac{7}{16}$ hours on three installations. How many total hours did the electrician work?

   Total hours worked = ____________

Related Math and Measuring
Unit 17

Assignment Sheet 8—Subtract Fractions

Name ______________________________ Overall Rating __________

Evaluation criteria	Rating
Completed all problems and showed work	_____
Labeled answers with correct unit of measurement	_____
Computed a minimum of 38 of the 43 answers correctly per Assignment Sheet 8 answers	_____

Directions for subtracting like fractions:

Example: Subtract 1/16 from 7/16.

1. Subtract smaller numerator from larger numerator.

   Example: 7 – 1 = 6

2. Place answer over common denominator.

   Example: 6/16

3. Reduce to lowest terms if required.

   Example: 6/16 = ⅜ Answer

Directions for subtracting unlike fractions:

Example: Subtract ½ from ¾.

1. Change to like fractions.

   Example: ¾ remains the same because 4 is the common denominator.

   ½ is multiplied by 2/2, or ½ x 2/2 = 2/4.

Assignment Sheet 8

2. Subtract as for like fractions and reduce to lowest terms if required.

   Example: $\frac{3}{4} - \frac{2}{4} = \frac{1}{4}$ Answer

Directions for subtracting mixed numbers:

Example: Subtract $3\frac{1}{2}$ from $5\frac{1}{8}$.

1. Change mixed numbers to like fractions.

   Example: $3\frac{1}{2} = 3\frac{4}{8}$

2. Borrow a 1 from the original whole number if needed, and convert the 1 to a like fraction, and add it to the smaller fraction.

   Note: This step is needed only if the like fraction in the original number is smaller than the like fraction in the subtracted number.

   Example: $5\frac{1}{8} - 3\frac{4}{8} = (4\frac{8}{8} + \frac{1}{8}) - 3\frac{4}{8} = 4\frac{9}{8} - 3\frac{4}{8}$

3. Subtract whole number from whole number and like fraction from like fraction, and reduce answer to lowest terms if required.

   Example: $4\frac{9}{8} - 3\frac{4}{8} = 1\frac{5}{8}$ Answer

Directions for subtracting a fraction from a whole number:

Example: $4 - \frac{3}{16}$

1. Borrow 1 from whole number.

   Example: $4 - 1 = 3$

2. Change borrowed 1 to like fraction.

   Example: $1 = \frac{16}{16}$

3. Subtract as for like fractions and reduce answer to lowest terms if required.

   Example: $3\frac{16}{16} - \frac{3}{16} = 3\frac{13}{16}$ Answer

Assignment Sheet 8

A. Subtract the proper fractions given below. Show your work in the spaces provided. Reduce to lowest terms if necessary. Write your answers on the blanks.

1. $\frac{3}{4} - \frac{3}{16} =$ ____________
2. $\frac{7}{8} - \frac{1}{4} =$ ____________
3. $\frac{30}{32} - \frac{3}{4} =$ ____________
4. $\frac{25}{32} - \frac{5}{8} =$ ____________
5. $\frac{7}{8} - \frac{2}{16} =$ ____________
6. $\frac{15}{16} - \frac{3}{8} =$ ____________
7. $\frac{1}{2} - \frac{7}{16} =$ ____________
8. $\frac{3}{4} - \frac{3}{8} =$ ____________
9. $\frac{13}{16} - \frac{9}{32} =$ ____________
10. $\frac{7}{8} - \frac{6}{16} =$ ____________

B. Subtract the following fractions from whole numbers. Show your work in the spaces provided. Reduce to lowest terms if necessary. Write your answers on the blanks.

1. $4 - \frac{3}{4} =$ ____________
2. $7 - \frac{15}{16} =$ ____________
3. $32 - \frac{13}{32} =$ ____________
4. $175 - \frac{4}{5} =$ ____________
5. $12 - \frac{61}{64} =$ ____________

Assignment Sheet 8

C. Subtract the following mixed numbers from whole numbers. Show your work in the spaces provided. Reduce to lowest terms if necessary. Write your answers on the blanks.

1. $2 - 1\frac{1}{3} =$ ____________
2. $3 - 1\frac{3}{8} =$ ____________
3. $18 - 9\frac{7}{8} =$ ____________
4. $3 - 1\frac{21}{32} =$ ____________
5. $27 - 1\frac{5}{16} =$ ____________
6. $14 - 6\frac{3}{4} =$ ____________
7. $5 - (3\frac{5}{32} + 1\frac{9}{32}) =$ ____________
8. $8 - (1\frac{1}{4} + 5\frac{5}{8} + \frac{1}{16}) =$ ____________
9. $4 - 3\frac{1}{3} =$ ____________
10. $42 - 3\frac{7}{16} =$ ____________

D. Subtract the following mixed numbers. Show your work in the spaces provided. Reduce to lowest terms if necessary. Write your answers on the blanks.

1. $1\frac{3}{5} - 1\frac{1}{5} =$ ____________
2. $72\frac{9}{16} - 22\frac{7}{16} =$ ____________
3. $7\frac{5}{6} - 2\frac{1}{6} =$ ____________
4. $18\frac{7}{8} - 9\frac{3}{8} =$ ____________

Assignment Sheet 8

5. $35\frac{5}{8} - 8\frac{1}{2} =$ ____________

6. $5\frac{1}{4} - (1\frac{1}{8} + 1\frac{7}{8}) =$ ____________

7. $12\frac{1}{2} - (7\frac{1}{4} + 3\frac{1}{8}) =$ ____________

8. $4\frac{29}{32} - 1\frac{19}{32} =$ ____________

9. $5\frac{15}{32} - 2\frac{31}{32} =$ ____________

10. $8\frac{1}{16} - 4\frac{7}{8} =$ ____________

E. Solve the following word problems. Show your work in the spaces provided. Reduce to lowest terms if necessary. Write your answers on the blanks.

1. Ross had a $\frac{7}{8}$-inch wrench. He needed a $\frac{3}{4}$-inch wrench. How much difference is there in the size of the wrenches?

   Difference in inches = ____________

2. Anita worked $5\frac{1}{4}$ hours on an installation, and Don worked $4\frac{1}{2}$ hours on the same installation. How much faster did Don work than Anita?

   Difference in hours = ____________

Assignment Sheet 8

3. An outlet is to be installed $4\frac{1}{2}$ inches from the floor. Two pieces of decorative baseboard will be installed under the outlet. If one piece of baseboard is $1\frac{5}{8}$ inches wide, how wide must the second piece be to touch the outlet?

   Width of baseboard in inches = ____________

4. Three pieces of conductor are cut from a piece $35\frac{1}{2}$ inches long. The lengths are $7\frac{1}{4}$ inches, $11\frac{3}{8}$ inches, and $6\frac{1}{2}$ inches. If $\frac{3}{8}$ inch of conductor is wasted in cutting, how much conductor is left?

   Length of conductor left in inches = ____________

5. A piece of rigid metal conduit is $32\frac{1}{2}$ inches long. Short pieces of the following lengths are cut from it: $6\frac{1}{2}$ inches, $5\frac{1}{4}$ inches, $8\frac{13}{16}$ inches, and $10\frac{9}{16}$ inches. How much conduit is left?

   Amount of conduit left in inches = ____________

6. A wash up tank has $16\frac{3}{10}$ gallons of solvent in it. After using $9\frac{3}{4}$ gallons, how many gallons will be left?

   Number of gallons = ____________

7. A container of solvent holds $4\frac{1}{4}$ liters. How much solvent is left after using $\frac{1}{2}$ liter to clean terminals before soldering?

   Number of liters = ____________

8. A conductor is $\frac{1}{2}$ inch by 10 inches. If $1\frac{3}{8}$ inches are cut from its length, what will be the final length of the conductor?

   Conductor length in inches = ____________

Related Math and Measuring
Unit 17

Assignment Sheet 9—Multiply Fractions

Name ______________________________ Overall Rating __________

Evaluation criteria	Rating
Completed all problems and showed work	_____
Labeled answers with correct unit of measurement	_____
Computed a minimum of 9 of the 11 answers correctly per Assignment Sheet 9 answers	_____

Directions: Solve the following multiplication problems.

Example: $\frac{2}{3} \times \frac{3}{4}$ becomes $\frac{2 \times 3}{3 \times 4} = \frac{6}{12} = \frac{1}{2}$

A. Multiply the following fractions. Convert mixed fractions where needed and reduce answers to lowest terms.

1. $\frac{1}{2} \times \frac{3}{4} =$ ________
2. $1\frac{1}{2} \times 2\frac{1}{4} =$ ________
3. $\frac{7}{8} \times \frac{2}{3} =$ ________
4. $\frac{1}{4} \times \frac{1}{3} \times \frac{1}{2} =$ ________
5. $\frac{3}{8} \times \frac{5}{16} =$ ________
6. $\frac{1}{2} \times 6\frac{1}{2} =$ ________
7. $1\frac{1}{3} \times 2\frac{1}{4} \times \frac{1}{2} =$ ________
8. $2\frac{3}{4} \times 6\frac{1}{8} =$ ________

Assignment Sheet 9

B. Solve the following word problems. Show your work in the space provided. Write your answers on the blanks.

1. A certain cleaning agent requires mixing ¾ gallon solvent and ¼ gallon water to make a gallon of cleaning agent. How much solvent should a worker use if she needs to mix only ⅓ gallon of the cleaning agent?

   Amount of agent = ____________

2. There are 296 dry-wall screws per pound. How many screws are there in ¼ pound?

   Number of screws = ____________

3. After completing an installation, a contractor has 8⅔ feet of conductors left in three different types. If one-half of the wires are neutral (green), how many neutral wires are there?

   Number of neutral wires = ____________

Related Math and Measuring
Unit 17

Assignment Sheet 10—Add Decimal Numbers

Name ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
Completed all problems and showed work	______
Labeled answers with correct unit of measurement	______
Computed a minimum of 35 of the 40 answers correctly per Assignment Sheet 9 answers	______

Directions: Solve the following decimal addition problems.

A. Write the name of the place for each *underlined* digit.

____________ 1. $867.\underline{4}3$

____________ 2. $6.3\underline{7}892$

____________ 3. $1.0000\underline{8}$

____________ 4. $6.239\underline{5}$

____________ 5. $0.47\underline{6}$

B. Write the name of the place for the last digit in each of the following numbers.

____________ 1. 0.38

____________ 2. 0.4678

____________ 3. 321.9

____________ 4. 427.389

____________ 5. 44.67

Assignment Sheet 10

C. Underline the digit that is in the place named in italics.

1.	46.3826	*Hundredths*	11.	5230.867	*Thousandths*
2.	35.0038	*Ten thousandths*	12.	587.029	*Ones (units)*
3.	148.296	*Tenths*	13.	0.298	*Hundredths*
4.	6756.23	*Hundredths*	14.	329.768	*Tens*
5.	91.4082	*Thousandths*	15.	52.694	*Thousandths*
6.	204.37	*Tens*	16.	498.276	*Tenths*
7.	14.0079	*Ones (units)*	17.	0.5296	*Ten thousandths*
8.	208.097	*Hundredths*	18.	468.539	*Hundreds*
9.	5.23981	*Thousandths*	19.	324.06	*Tenths*
10.	502.967	*Tenths*	20.	567.8	*Ones (units)*

D. Set up the following groups of numbers in columns. Add each column, carrying when necessary and placing the decimal point correctly.

1. 0.024 + .165

2. 87.3 + 370

3. 15.127 + 3.4 + .0091 + 236.87

4. 195.7 + 83 + 9.006

5. .5280 + 435 + 179.50 + 1.9

Assignment Sheet 10

E. Solve the following word problems. Show your work in the spaces provided. Write your answers on the blanks.

1. Motoaki earned $22.50 on an installation, and Maria earned $16.50. How much did they earn together?

   Total amount earned = ____________

2. On an installation, labor costs $54.65, parts cost $16.30, and the tax is $3.38. What is the total cost of the job?

   Total cost = ____________

3. Octavia worked four days on a certain project. She worked 6.8 hours Monday, 7.4 hours Tuesday, 5.3 hours Wednesday, and 4.4 hours Thursday. How many total hours did she work?

   Total hours worked = ____________

4. Frank was cleaning out the storage bin. He found three partially used bottles of solvent, each containing the following amounts: 6.7 liters, 12.9 liters, and .5 liters. How many total liters of solvent were stored?

   Total liters of solvent = ____________

5. In one month, an electrical contractor has the following expenses: equipment and supplies, $286.96; fixtures, $142.37; electric bill, $160.16; telephone, $116.27; and labor, $15,312.50. What was the contractor's total monthly expenditure?

   Total monthly expense = ____________

Related Math and Measuring
Unit 17

Assignment Sheet 11—Subtract Decimal Numbers

Name ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
Completed all problems and showed work	______
Labeled answers with correct unit of measurement	______
Computed a minimum of 12 of the 15 answers correctly per Assignment Sheet 11 answers	______

Directions: Solve the following decimal subtraction problems.

A. Set up each of the following problems in column form. Subtract and check your work. Remember, when you subtract decimals, the decimal points must be aligned.

1. 868.87 – 516.89 = ___________

2. 567 – 19.856 = ___________

3. 198 – 56.987 = ___________

4. 567.94 – 59.78 = ___________

5. $815.23 – $65.98 = ___________

Assignment Sheet 11

6. $20.03 – $15.88 = ___________

7. 694.7 – 24.3 = ___________

8. 5,000 – 892.66 = ___________

9. $15 – $12.53 = ___________

10. $219.30 – $21.85 = ___________

B. Solve the following word problems. Show your work in the spaces provided. Write your answers on the blanks.

1. An electrical contractor received $8438.64 in December, and paid out $5121.32 in January. How much profit did the shop make?

   Profit = ___________

2. It takes 20.5 hours to finish a job. Sean has worked 6 hours. How much longer will it take him to finish the job?

   Hours required to finish job = ___________

Assignment Sheet 11

3. A length of metallic tubing 6.14 centimeters long was cut from a tube 8.98 centimeters in length. How much tubing was left?

   Centimeters of hose left = ____________

4. A water cooler holds 49.2 liters of water. After a day, workers have drunk 8.7 liters. How much water is left in the cooler?

   Liters of water in cooler = ____________

5. You have a piece of conduit with a length of 27.5 inches, but the conductors to be run in it are 55 inches long. How many more inches must the conduit be to accomodate the wires?

   Inches = ____________

Related Math and Measuring
Unit 17

Assignment Sheet 12—Multiply Decimal Numbers

Name ______________________________ Overall Rating __________

Evaluation criteria	Rating
Completed all problems and showed work	______
Labeled answers with correct unit of measurement	______
Computed a minimum of 16 of the 18 answers correctly per Assignment Sheet 12 answers	______

Example:

$$\begin{array}{rl} 16.11 & \text{2 Decimal Places} \\ \underline{\times\ 2.2} & \text{1 Decimal Place} \\ 3222 & \\ \underline{3222} & \\ 35.442 & \text{3 Decimal Places in Answer} \end{array}$$

A. Set up each of the following problems in column form and multiply. Locate the decimal point in the answer.

1. 2.64 × 3.1 = ____________

2. 120 × 0.33 = ____________

3. 2.25 × 0.51 = ____________

4. 35 × 8.5 = ____________

5. 26.4 × 3.8 = ____________

Assignment Sheet 12

6. 7.02 × 0.92 = ____________

7. 0.83 × 0.55 = ____________

8. 28.2 × 0.9 = ____ ________

9. 0.069 × 0.01 = ____________

10. 7.52 × 3.01 = ____________

B. Solve the following word problems. Show your work in the spaces provided. Write your answers on the blanks.

1. A tool kit is placed on sale for 25 percent off. By what amount is the price reduced if the regular price is $1349.80?

   Note: Twenty-five percent is the same as the decimal .25.

   Price reduction = ____________

2. The average cost of a replacement part is $41.25. During the year, the electrician installs 150 such parts. What is the total cost?

   Total average cost = ____________

3. What is the total distance traveled at 1.3 km/h if the trip took .6 hours?

   Kilometers traveled = ____________

Assignment Sheet 12

4. What is the total length of 7 pieces of wiring if each piece is .04 meters long?

Length in meters = ___________

5. What is the cost of 15 gallons of solvent at $1.13 per gallon?

Cost = ___________

6. If faceplates cost 78¢ each, what is the cost of 2 dozen faceplates?

Cost = ___________

7. An electrical contractor is adding a work area 16.4 meters long by 11.5 meters wide. How many square meters large will the area be?

Size in square meters = ___________

8. Carmelita completed 6 wiring installations in the last five days. She worked 5.6 hours the first day, 3.8 hours the second day, 4.4 hours the third day, 2 hours the fourth day, and 6.6 hours the fith day. Using this 5-day period as an average, how many hours would Carmelita work over a 15-day period?

Hours = ___________

Related Math and Measuring
Unit 17

Assignment Sheet 13—Divide Decimal Numbers

Name ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
Completed all problems and showed work	_____
Labeled answers with correct unit of measurement	_____
Computed a minimum of 13 of the 15 answers correctly per Assignment Sheet 13 answers	_____

A. Divide numbers in the following problems. Show your work. Write your answers on the blanks provided.

1. 4.5 ÷ 0.5 = ___________

2. 4.96 ÷ 0.4 = ___________

3. 19.8 ÷ 0.6 = ___________

4. 10.71 ÷ 0.07 = ___________

5. 0.225 ÷ 0.15 = ___________

6. 1.7608 ÷ 0.0062 = ___________

Assignment Sheet 13

7. $0.48 \div 0.6 =$ ____________

8. $0.125 \div 0.25 =$ ____________

9. $0.9 \div 0.003 =$ ____________

10. $1.16 \div 2.9 =$ ____________

B. Solve the following word problems. Show your work in the spaces provided. Write your answers on the blanks.

1. What is the approximate cost per fixture if the cost of twelve fixtures is $103.68?

   Approximate cost = ____________

2. How many hours did Jana work if she was paid a total of $681.75 at the rate of $22.50 per hour?

   Total hours = ____________

3. How many jobs can be completed in 21.12 hours if the average job takes .066 hours?

   Number of jobs = ____________

4. Curt spent $172.80 for equipment. What was the cost per piece if he bought eight pieces of equally priced equipment?

   Cost per piece = ____________

Assignment Sheet 13

5. A shipment of 114 identical fixtures has arrived at Mr. Kinski's electrical shop. Mr. Kinski pays the carrier $544.98 for all of them. How much does 1 fixture cost?

Cost of 1 fixture = ____________

Related Math and Measuring
Unit 17

Assignment Sheet 14—Convert Fractions and Percentages

Name ______________________________ Overall Rating ________

Evaluation criteria	**Rating**
Completed all problems and showed work	______
Labeled answers with correct unit of measurement	______
Computed a minimum of 54 of the 60 answers correctly per Assignment Sheet 14 answers	______

Directions: Solve the following conversion problems.

A. Express each of the following fractions as a decimal.

1. $\frac{1}{8}$ = ____________
2. $\frac{1}{4}$ = ____________
3. $\frac{1}{2}$ = ____________
4. $\frac{3}{4}$ = ____________
5. $\frac{5}{8}$ = ____________
6. $\frac{1}{16}$ = ____________
7. $\frac{3}{32}$ = ____________
8. $\frac{7}{8}$ = ____________
9. $\frac{9}{16}$ = ____________
10. $\frac{15}{16}$ = ____________

Assignment Sheet 14

B. Express each of the following fractions as a percentage.

1. $^{1}/_{4}$ = ____________
2. $^{1}/_{2}$ = ____________
3. $^{7}/_{10}$ = ____________
4. $^{3}/_{4}$ = ____________
5. $^{2}/_{2}$ = ____________
6. $^{1}/_{10}$ = ____________
7. $^{7}/_{8}$ = ____________
8. $^{5}/_{10}$ = ____________
9. $^{1}/_{3}$ = ____________
10. $^{5}/_{8}$ = ____________

C. Match the decimal numbers on the right with their correct equivalent fractions. Write the correct letters in the blanks.

______1.	$5^{6}/_{10}$	a. 7.083
______2.	$1^{2}/_{100}$	b. 5.006
______3.	$^{87}/_{1000}$	c. 78.3
______4.	$7^{83}/_{1000}$	d. 0.087
______5.	$5^{6}/_{100}$	e. 0.783
______6.	$5^{6}/_{1000}$	f. 87.7
______7.	$78^{3}/_{10}$	g. 5.6
______8.	$87^{7}/_{10}$	h. 102.0
______9.	102	i. 5.06
______10.	$^{783}/_{1000}$	j. 1.02

Assginment Sheet 14

D. Write decimal equivalents for each of the following fractions.

1. $63\frac{9}{10}$ = ____________
2. $5\frac{93}{100}$ = ____________
3. $5\frac{93}{1000}$ = ____________
4. $5\frac{93}{10000}$ = ____________
5. $3\frac{825}{1000}$ = ____________
6. $38\frac{95}{100}$ = ____________
7. $38\frac{95}{1000}$ = ____________
8. $42\frac{3}{10}$ = ____________
9. $402\frac{3}{10}$ = ____________
10. $897\frac{97}{100000}$ = ____________

E. Express each of the following percentages as a fraction. Reduce to the lowest terms.

1. 50% = ____________
2. 25% = ____________
3. $33\frac{1}{3}$% = ____________
4. 36% = ____________
5. 28% = ____________
6. $14\frac{2}{7}$% = ____________
7. 21% = ____________
8. 75% = ____________
9. $66\frac{2}{3}$% = ____________
10. 70% = ____________

F. Express each of the following percentages as a decimal.

1. 47% = ____________
2. 15% = ____________
3. 33.3% = ____________
4. 62% = ____________
5. 75% = ____________
6. 3% = ____________
7. 16.8% = ____________
8. 9% = ____________
9. 10% = ____________
10. 50% = ____________

Related Math and Measuring
Unit 17

Assignment Sheet 15—Solve Percentage Problems

Name ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
Completed all problems and showed work	_____
Labeled answers with correct unit of measurement	_____
Computed a minimum of 25 of the 29 answers correctly per Assignment Sheet 15 answers	_____

Directions: Calculate the answers to the following percentage problems.

A. What does it mean to say 100 percent of the work is completed? ______________

____

B. There are usually 100 tools in the tool shed. Fourteen of them are missing. What percent of the tools is missing? ______________

C. If 14 of the tools are missing in the above problem, how many are present? ______

What percent is present? ______________

D. There are 100 boxes in a carton. Twenty-five boxes are what percent of the boxes in the carton? ______________

Five boxes are what percent of the boxes in the carton? ______________

E. There are 100 jobs on the agenda. Ninety-four have been completed. What percent of the jobs have been completed? ______________

Assignment Sheet 15

F. If 94 of the jobs in the above problem have been completed, how many have not been? ____________________

What percent has not been completed? ____________________

G. If 11 percent of the students in a school are absent, what percent are present? ____________________

H. If 6 percent of the reamers that a store had in stock were not sold, what percent were sold? ____________________

I. If 60 percent of the electricians in town had assistants, what percent did not have assistants? ____________________

J. Bill has a set of electrician's tools. Ten percent of his tools are a year old, and 40 percent are over a year old. What percent are less than a year old? ____________________

K. Nicole has three types of screwdrivers—flat, Philips, and square. Eighty percent of her screwdrivers are flat, and 15 percent are square. What percent are Philips? ____________________

L. The Clarks spent 22 percent of their income for their business: 17 percent for tools, 15 percent for work clothes, and 8 percent for overhead. What percent was left for other things? ____________________

M. Hyun-lee has finished 75 percent of the job he is doing. What percent does he still have to do? ____________________

N. Marie has completed 40 percent of her training. What percent does she still have to do? ____________________

O. If you were told to complete 93 percent of the work, what percent would be left? ____________________

Assignment Sheet 15

P. Solve each of the following percentage problems.

1. 3% of 72 is what number? ____________
2. 5% of 18 is what number? ____________
3. What number is 33⅓% of 96? ____________
4. 40% of 125 is what number? ____________
5. 68% of 63.5 is what number? ____________
6. What number is 12½% of 140.8? ____________
7. What number is 1% of 103? ____________
8. What number is 37½% of 152? ____________
9. 50% of 32.8 is what number? ____________
10. 7% of 163 is what number? ____________

Q. Solve the following percentage word problems.

1. There are 20 students in a class. Sixty percent of the students are boys. How many are boys? ____
2. One day 5 percent of the 20 electricians in Mr. Washington's group made perfect time completing a job. How many electricians made perfect time? __________
3. Contractor McGill bought a new power threader—regularly selling for $120—at a sale and saved 20 percent. How much money did he save? ____________
4. The number of electricians at the meeting this year was 75 percent of what it was last week. Last year there were 800 electricians at the meeting. How many electricians were at the meeting this year? __________________________

Related Math and Measuring
Unit 17

Assignment Sheet 16—Calculate Area

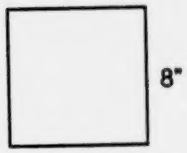
Name ______________________________ Overall Rating __________

Evaluation criteria	Rating
Completed all problems and showed work	______
Labeled answers with correct unit of measurement	______
Computed a minimum of 21 of the 24 answers correctly per Assignment Sheet 16 answers	______

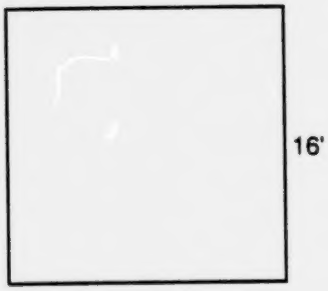
Directions: Calculate area for the following problems.

A. Calculate the area for each of the following squares.

1.



2.



A = ____________

A = ____________

3. Square = 15 feet

4. Square = 36 yards

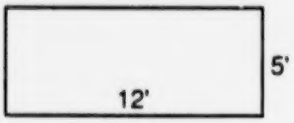
A = ____________

A = ____________

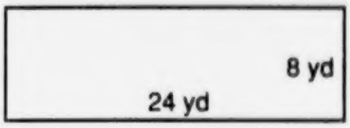
Assignment Sheet 16

B. Calculate area for each of the following rectangles.

1.



2.



A = ____________

A = ____________

3. L = 17"; W = 31"

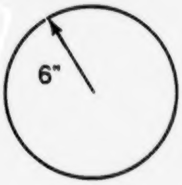
4. L = 16'; W = 62'

A = ____________

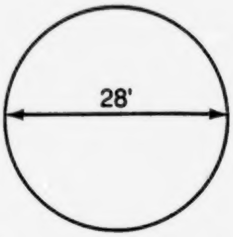
A = ____________

C. Calculate area for each of the following circles. (Use π = 3.14.)

1.



2.



A = ____________

A = ____________

Assginment Sheet 16

3. Radius = 16′

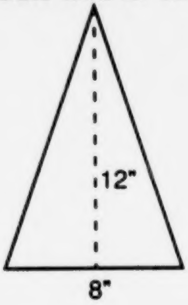
4. Diameter = 25 yards

A = ____________

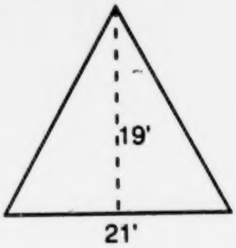
A = ____________

D. Calculate area for each of the following triangles.

1.



2.



A = ____________

A = ____________

3. b = 13″; h = 3″

4. b = 24 yards; h = 15 yards

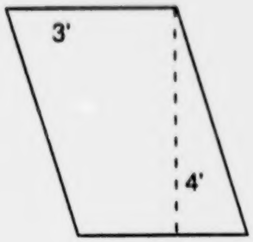
A = ____________

A = ____________

Assignment Sheet 16

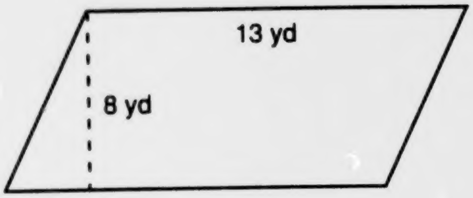
E. Calculate area for each of the following parallelograms.

1.



A = ____________

2.



A = ____________

3. b = 16″; h = 16″

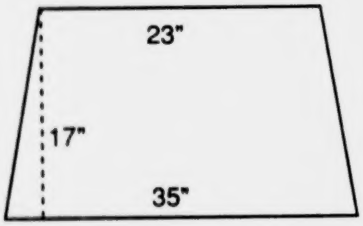
A = ____________

4. b = 27 yards; h = 9 yards

A = ____________

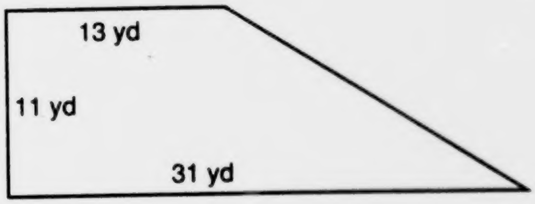
F. Calculate area for each of the following trapezoids.

1.



A = ____________

2.


13 yd
11 yd
31 yd

A = ____________

Assignment Sheet 16

3. $h = 12'; b_1 = 9'; b_2 = 19'$

4. $h = 17$ yards; $b_1 = 39$ yards; $b_2 = 51$ yards

A = ____________

A = ____________

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